S. A. E. JOURNAL

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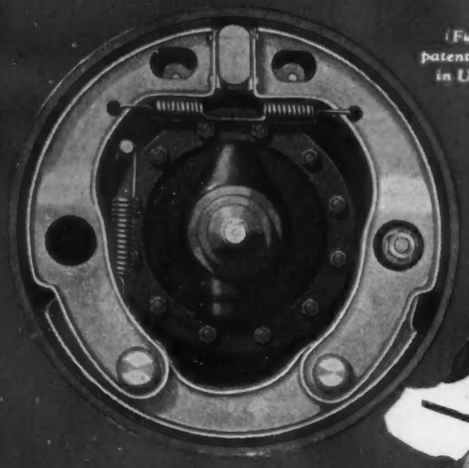
The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.



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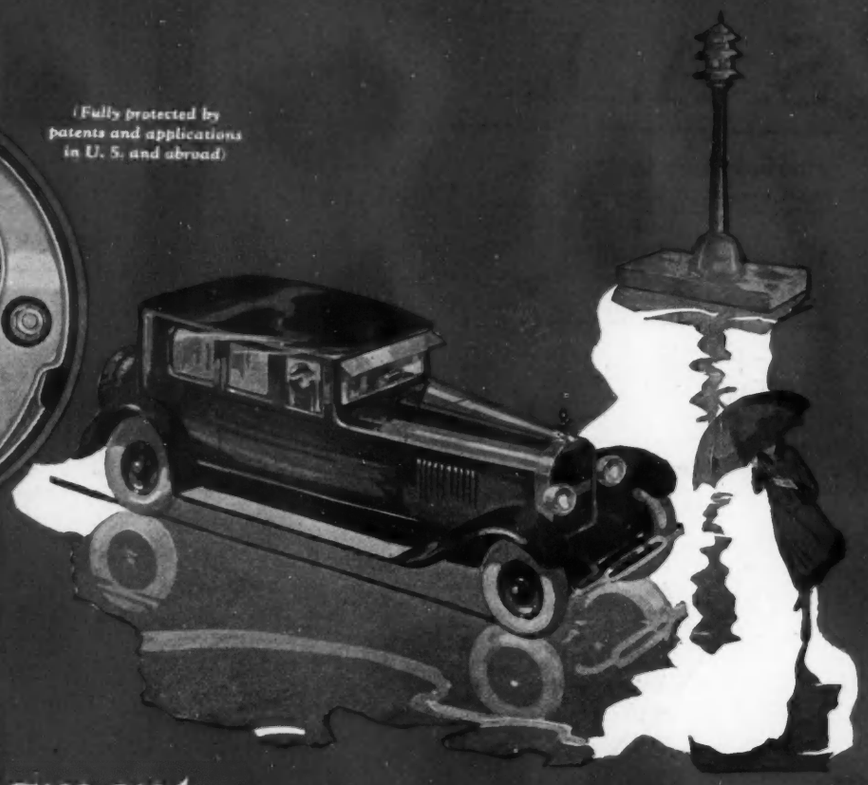

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S. A. E. JOURNAL

Vol. XXIII July, 1928 No. 1

The 1928 Summer Meeting

First S.A.E. Foreign Convention—Sightseeing Trips Are a Feature—Attendance of 851 Breaks Record

BY Wednesday, June 27, more than 800 members had arrived in Quebec by motor-car and special and regular trains for the first S.A.E. Convention ever held on foreign soil. This was the largest attendance at any Summer Meeting ever held so far from the geographical center of the industry. The Detroit and New York Specials arrived early Tuesday morning, having been preceded by more than 100 of the members, many of whom drove up from the States. The feature of the Detroit Special was the baggage-car, decorated as a night club by Gay Hall, whose name, to quote the *Daily SAE*, again published by the Delco-Remy Corporation, "is a heck of a swell name for a night-club decorator." Dance music was provided without stint, as reported by the *Daily SAE*, by "Phil Overman's Non-Recording Hi-Tone High-Hat Orchestra. Assisting Banjo Phil were: Charles A. Pokorny, saxophone addict; Ed. W. Griffith, double bass umpah; D. E. Anderson, trapper; H. A. Hansen, fiddler; Bunny Dawe, slip horn, and Fred A. Cornell, pipe organ." The Detroit High-Hats also played at sundry other unscheduled times during the Summer Meeting.

A feature of the New York Special was a paper printed by Sid Dresser and special menus carrying cartoons of the Section officers.

Hon. Edward P. Warner, Assistant Secretary of the Navy for aeronautics, arrived Wednesday morning in a Vought Corsair, alighting in the St. Lawrence River, despite the low visibility which he said at one time made him consider turning back.

Much credit is due to the Chateau Frontenac and its management for the excellent facilities and service extended to the Society. The public rooms, the Convention hall, and the location of the Chateau on Dufferin Terrace overlooking the city and the river helped to make the meeting one that will be remembered for many years.

Another innovation was a departure from the usual registration badge, the maple leaf, the National emblem of Canada, being used. It is reproduced elsewhere in this account. The photographs, which form a pictorial news account of the meeting, were taken by Nathan Lazarnick.

Another innovation, in connection with the technical sessions, was the use of a public-address system purchased by the Society at the direction of the Council, because of the difficulty of hearing speakers clearly in the rear of the meeting rooms at previous meetings, especially during the Annual Meeting in Detroit. This proved very successful and it is believed that the use of the system at future meetings of the Society will be greatly appreciated.

Another successful Summer Meeting has passed into history, and Quebec deserves recognition for having provided a most unusual and interesting environment for the enjoyment, education and inspiration of a very representative portion of the Society's membership.

Owing to the many unique attractions that abound at Chateau Frontenac and neighboring points of interest, the feminine and juvenile contingent of the Society gained more than usual pleasure from the convention in Canada.

Although the variety of offerings characteristic of Quebec may have diminished somewhat the attendance at technical sessions, it is nevertheless felt that the members whose votes swung the Summer Meeting to Quebec made a wise selection.

The nights were short and the days were shorter; yet the Summer Meeting undoubtedly accomplished in large measure the purpose for which it was intended.—John A. C. Warner, chairman, Meetings Committee.

Souvenirs

THE ladies attending the Summer Meeting were pleasantly surprised on Wednesday evening to receive from the Society, with the compliments of President William Guy Wall, an enamel mesh-bag bearing the maple leaf of Canada. These bags were in evidence throughout the rest of the meeting, a sure sign that they had made a hit with the ladies.

Souvenirs were also given out by the Stewart-Warner Speedometer Corporation, these being electric cigar-lighters, in attractive boxes, ready for installa-

tion on the instrument board. The Houde Engineering Corporation, appreciating that the members were playing a foreign course, gave out golf balls. Another courtesy that was greatly appreciated at the meeting was the free gasoline supplied to members by A. Ludlow Clayden of the Sun Oil Co., a tank wagon being stationed just outside the Chauteau Frontenac grounds. This unannounced filling station was well patronized.

Country Fair Proves a Riot

Rural Costumes Enhance the Realism of Varied Sections Stunts

TO the tune of "Step right up, ladies and gents, and see Wild Rose"—"Try your luck at the shooting gallery"—"Get a prize from the wheel of fortune"—"What will you have, gents?" the crowd surged into the S.A.E. Country Fair in the grand ballroom of the Chateau Frontenac on Tuesday night.

Ten attractions, presided over by ballyhoo artists of no mean ability, provided entertainment for one of the biggest gatherings of the meeting. A large number of guests were clad in very ingenious costumes, ranging from Farmer Brown, with his wife and three farmerette daughters, to elaborate confidence men with 14-karat brass watch-chains. And right here mention must be made of Organ Grinder John Warner and his monkey and pig. What became of the monkey and also of the pig is known, but no one has been able to determine what happened to the squeal.

The writhing hula dancer, Wild Rose, as presented by the Detroit Section, made Gilda Gray look as though she stands still when she dances. Wild Rose, in actual bulk, was Clyde Wisenburgh, who was ably assisted in his contortions by the seductive Oriental music provided by Phil Overman, C. A. Pokorny, Bunny Dawe and D. E. Anderson. The ballyhoo of J. W. Bartholomew stole most of the customers from all the other attractions both times the show was presented. It should be added that Wild Rose had some serious competition in the form of two pages to open the curtain who provided eye entertainment and anticipation while the orchestra played before Wild Rose made *his* appearance.

Those whose throats got dry while watching Wild Rose were amply refreshed by a trip to Cap Risley's bar, where their thirst was assuaged by Bartender Joe McDermott, drafted by the Pennsylvania Section from the hotel staff. Henry Coleman was on hand to see that everybody got enough.

Those who liked Canadian cigarettes well enough to shoot at and for them were provided with pop guns and corks by "Buffalo Bill," listed in the S.A.E. Roster as Jack White. The Buffalo Shooting Gallery proved a real attraction, even though those who were awarded the packages of cigarettes for their marksmanship gave them away rather than take a chance smoking them.

Washington Section exhibited as much ingenuity in the choice of personnel as one could desire. It not only had H. H. Allen as a barker to attract the crowd to the wheel-of-fortune, but even went to the extent of borrowing John Younger from Cleveland to make sure that the prizes were not given out too fast. This combination dispensed

THE MAPLE-LEAF BADGE USED

oil-cans, soap babies, safety-pins, and what have you to the lucky (?) winners.

REVELATIONS OF PEEPHOLE SHOW

It is impossible to give proper praise to the Peephole Show put on by the New England Section, wherein one was enabled to discover that suspenders are "for men only," that "engineers in conference" are a bunch of nuts around a table, and that when you make a "connection with a western plant," you should make sure that it is not a cactus. Many of the crowd discovered that Darwin was right when they looked through one of the peepholes, and that Chinese are regarded mainly as a bunch of washers. Credit for the exceedingly clever exhibit is due to Glenn S. Whitham, W. M. Clark, Albert Lodge, K. T. Brown, M. R. Wolfard and F. N. Herlihy.

The ghost of Brown's at French Lick haunted the Country Fair at the Cleveland booth, wherein such efficient gamblers as A. K. Brumbaugh, S. L. Bradley, C. T. Klug, A. A. Skinner and H. R. Portugal showed how easy it was to make money at chuck-a-luck and roulette—provided you didn't lose. Fifty thousand dollars in paper money was distributed among the guests as they entered the Fair, and prizes were awarded to those who could collect, win, beg, buy, borrow or steal the greatest amount before the close of this large evening.

THE FUEL-LESS ENGINE MARVEL

The much-talked-of fuel-less engine was exhibited and operated in the Milwaukee Section booth by Messrs. Starck and Debbink, whose explanation of its characteristics may have been adequate but was entirely unconvincing as to whether its greatest efficiency would be developed in motor-cars or in airplanes. This is a terrifically interesting device which it is recommended be given serious consideration.

Those who like to play with babies were given an opportunity to throw perfectly good embroidery rings over the heads of Eisinger's dolls in the Chicago Section booth. Prizes were distributed according to the degree of success attained. This booth provided a great deal of entertainment, particularly for wives practising for skill in throwing things.

The prizes which were to be given out by the Chicago Section were not imported into Canada owing to the heavy duty involved. The winners of the prizes were therefore asked to leave their names and addresses at the S.A.E. Information Desk so that the prizes might be mailed to them upon their return home.

Many are still wondering why those who made such a slow entrance into the mysterious black tunnel of the Metropolitan Section booth made such a hurried exit. From the location of the mattress outside the door it seemed likely that some physical assistance was premeditated. Many members took the opportunity to lead some of their friends to the entrance and leave them in the hands of Sandy and Gordon Brown for disposition. Truly this was a wonderful opportunity.

THE INDIANAPOLIS RACE

The Indiana Section stunt, the initial feature of the Country Fair, was the "Indianapolis Race," wherein the destinies of six cars over the race track were guided by six sweet young things, the progress of the cars being decided by the dice-throwing ability of the drivers. The spectators holding tickets bearing the number of the winning car had their tickets thrown into a hat and the winning numbers were drawn for first, second and third prizes. Credit for devising and operating this ingenious scheme belongs to

TO QUOTE *THE DAILY SAE*, THE COUNTRY FAIR WAS A WOW

Fay Chandler, Who Had Charge of the Leasing of the Concessions to the Sectionnaires, Appears Directly Opposite to H. A. Brown, Jr.'s Three Farmerettes. The Bar, with Cap Risley Disguised as Dead-Eye Dick, Proved Popular. The Fuel-Less Engine, Exhibited by the Milwaukee Section, Was Nonsensically Elucidated by W. A. Starck, H. L. Debbink and F. M. Young. The New England Section Penny Arcade, Where Engineers Discovered What Even Their Closest Friends Wouldn't Tell Them, Looked Intriguing. The Indiana Section Stunt Was a 500-Mile-Race Riot. Real Prizes Were To Be Obtained from the Chicago Section Booth, Where J. W. Tierney, A. C. Nuth and J. O. Eisinger Supervised the Ringing of Dolls with Leaden Feet

R. P. Lewis, Louis Schwitzer, T. J. Litle, Jr., Fred Duesenberg, F. E. Moskovics, W. H. Hunter, R. C. Root, and Fay Chandler.

Dancing was in order as soon as the Indiana Race Track was cleared, but the Sectionnaires did a Coney Island Sunday business until the lights went out.

As stated by the *Daily SAE*, "take it by and large, fore and aft, up and down, it was a great show with a real cast. It takes real brains to be successfully foolish."

What the Sightseers Saw

Historic and Typically French Scenes in the City—Montmorency Falls and Ste. Anne de Beaupré

WHAT Quebec lacks in the way of facilities for outdoor sports close to the hotel, which have characterized the Summer Meetings at White Sulphur Springs and French Lick, was more than made up by the city as a place of interest to sightseers. Of the organized trips scheduled for the members and the lady visitors during the meeting no comparison can be made as to relative interest, as all were so different in character. The observation motor-coach trip in and about the city on the first day, taken by about 150 members and visiting ladies in seven or eight coaches, provided an excellent introduction to the quaint old European city in the New World, with its narrow, hilly streets, its French-type stone and brick houses built in solid rows with their flat fronts and shuttered windows, and the street names and store signs in French. Starting in front of the Chateau on the east bluff of the hill, the trip took in the upper-level streets where are located both the oldest and the most modern structures, and then the lower level below the old fortifications.

Great historic interest centers in the old walled city, with its three restored city gates on the west, the citadel built 100 years ago by the British at a cost of $35,000,000 and never since required for defence of the city, the Plains of Abraham where Wolfe and Montcalm fought and were both mortally wounded, and the 250-year-old house used as headquarters by Montcalm and in which he died.

Of political and civic interest were the Parliament Buildings just outside the city wall, the City Hall, Post Office and lower-level Government buildings, including the Government - operated liquor depots. Of particular interest on the religious side were the old English cathedral, the old French Basilica, the Hotel Dieu Hospital founded in 1639, St. Matthews high church of England, and numerous Catholic churches, convents, orphanages, and the like.

To the west, out beyond the battlefield of 150 years ago on the Plains of Abraham and toward the Quebec Bridge, whose construction cost 90 or more lives as the result of collapses of the south approach in 1907 and the center span in 1916, the visitors rode through the grounds of Spencer Wood, the home of the Lieutenant Governor of Quebec Province, although the home itself was closed to the public because of a recent death in the family of the Lieutenant Governor.

Montmorency Falls and Kent House

On the forenoon of the second day an electric-car ride of about 8 miles down the shore of the St. Lawrence took more than 100 of the visitors to beautiful Montmorency Falls, where the water plunges 275 ft. in a snow-white cataract and then flows slowly out in a broad black stream into the St. Lawrence River and the Gulf of St. Lawrence, carrying with it many short lengths of pulp wood to feed the great pulp mill at Quebec. Because of rain, instead of following the river road, the cars were routed along the upper urban road to Kent House, residence of the Duke of Kent, father of Queen Victoria, during his sojourn in Canada from 1791 to 1794, but first occupied by Chartier de Lotbinière and the headquarters of Wolfe in 1759 prior to his capture of Quebec.

Teddy Denniss, Who Announced the Sightseeing Trips and Sessions

Just back of Kent House is the Kent golf course, on which, together with the Quebec course, the golf tournament of the Summer Meeting was held.

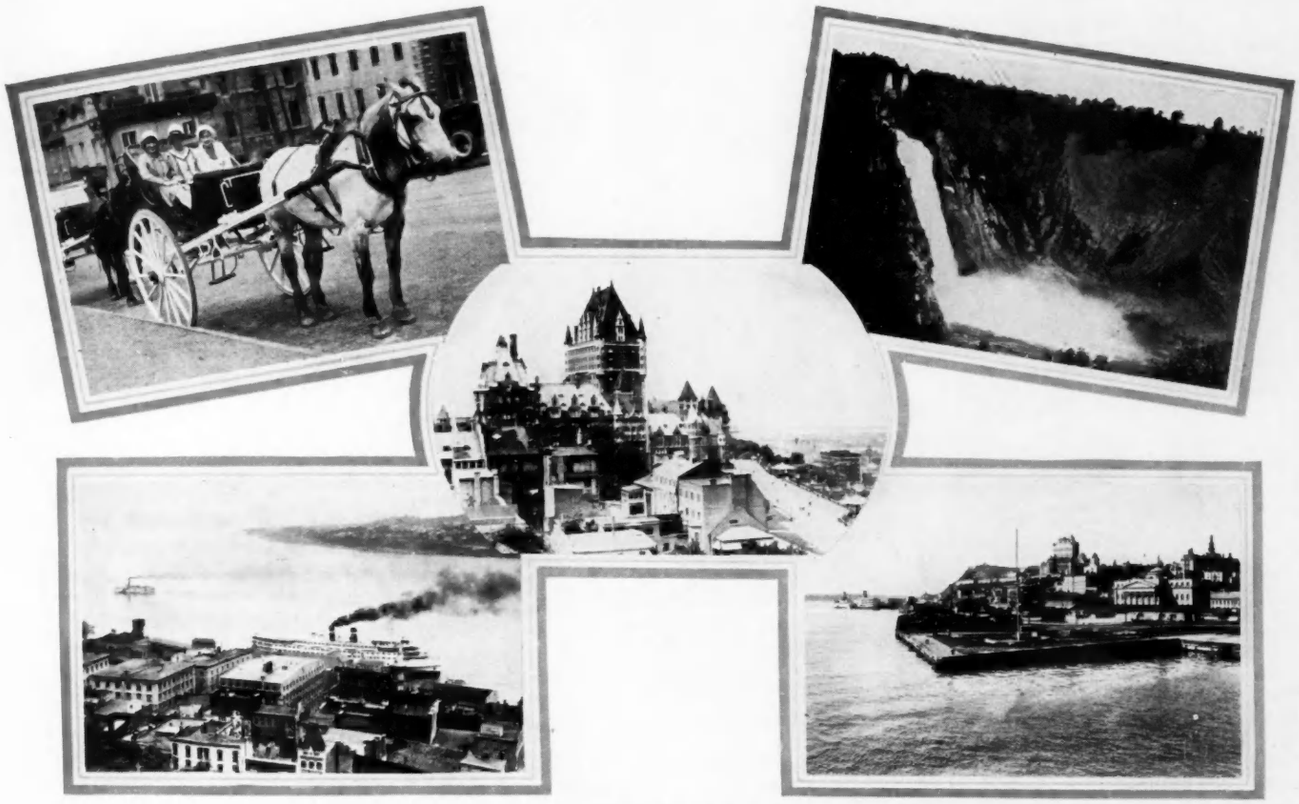
At Ste. Anne de Beaupré

Taking the suburban electric-train line on Thursday afternoon past Montmorency Falls, the visitors rode 21 miles along the west shore of the St. Lawrence through summer residence and farming country to the famous old village and shrine of Ste. Anne de Beaupré. Here the objects of interest were the magnificent new cathedral 325 ft. long by 200 ft. wide that has been erected and is now nearing completion to replace the temple which was destroyed by fire; the Scala Sancta, or holy stairway which the devout Catholics who make pilgrimages to the shrine from all parts of the world ascend slowly on their knees while offering prayers; the new monastery back of the new cathedral; the shrine in the basement of the cathedral which is being used pending completion of the structure; the Royal Museum where are displayed old paintings and relics given to the church, some of the crutches and other articles left by cripples who have been miraculously cured of their infirmities at the shrine of Ste. Anne; and the cyclorama of the crucifixion of Christ, a panoramic painting 360 ft. in circumference by 45 ft. in height presenting a marvelously beautiful and lifelike perspective of the city of Jerusalem and the crucifixion outside of the walled city.

Unscheduled Sightseeing

Picturesque one-horse, high-seated, two-wheeled caleches that in themselves are a unique sight enticed some of the visitors to explore the city of Quebec independently, mainly for the novelty of the ride. The whole city, however, does not afford a sufficiency of these survivals from bygone days to accommodate at one time all of those at the Summer Meeting who would want to go on such a trip in an organized party.

To many others one of the most interesting sightseeing excursions was a trip afoot through the old city citadel where the 33rd Canadian infantry company is stationed and where the archery tournament of the meeting was held in the old moat around the inner defence wall. In its day the citadel doubtless was an impregnable fortification and would have afforded protection to the inhabitants of the city, with which it was connected by underground passages, some a mile in length.



SOME OF THE QUEBEC VIEWS THAT WILL LONG BE REMEMBERED

Model 1800 High-Center-of-Gravity 1-Hp. Quebec Taxi, and, at the Upper Right, Montmorency Falls as Seen from Afar. (Center) The Chateau Frontenac, Where Members Spent Part of Their Time and Kept Fairly Dry When It Rained on the Golf Courses. (Bottom) Broad Reaches of the St. Lawrence as Seen from the Chateau, with Levis and the Isle d'Orleans in the Offing and the Saguenay River Steamer Richelieu; and View of the "Gibraltar of America" from the St. Lawrence

As a result of the excellent engineering of A. S. McArthur, superintendent of the Toronto Transportation Commission and chairman of the Summer Meeting Sightseeing Committee, the charabanc trip around the city and the electric-train trips to Montmorency Falls and Ste. Anne de Beaupré were highly successful. Arrangements for the trips were made through W. A. Lynch, assistant manager of the Quebec Railway, Light & Power Co., which operates all the transportation facilities, if the caleches and the Dufferin Terrace inclined railroad are not classified as such.

Rain interfered somewhat with viewing Montmorency Falls on Wednesday, but by way of compensation, the railway company stopped the special train below the falls on the way to Ste. Anne the following day.

SEEN ON THE SAGUENAY TRIP

Warned by many under no circumstances to fail to take the wonderful Saguenay River trip if time permitted, a considerable number of the Summer Meeting attendants stayed over for this post-convention cruise, which started early Saturday morning. After an all-day ride down the broad Gulf of St. Lawrence, with a stop at Murray Bay, they arrived about supper time at Tadousac, a little French village on a bay where the Saguenay flows into the St. Lawrence, its entrance guarded by Point aux Bouleaux and Point aux Vaches. Chief interest in this village lies in the fact that it is the oldest settlement in Canada and was once the rendezvous of Indians, fur traders and explorers and that the first church in America was founded there.

During the early evening the trip up the Saguenay was made to St. Alphonse, or Bagotville, the terminus of the through steamers from Montreal and a point of considerable lumber and pulp industry development in recent years. The marvelous scenery along the river was, however, the great attraction. Chicoutimi, at the head of navigation about 60 miles below Lake St. John, was the turning point of the trip. The little town is charmingly situated on a hill at the junction of the Chicoutimi and Saguenay Rivers, and was one of the earliest Jesuit missions in America and a great fur-trading center. The name means in the Indian language that "up to here it is deep," which is not to be doubted when it is learned that the Saguenay is 1½ miles deep, indicating a great cataclysm of nature. The deep, dark, mysterious river, flanked by towering mountains of rock rising to heights of 1800 ft. at Capes Trinity and Eternity, which seemed to menace the steamer as it skirted the base, affords one of the most glorious scenic trips on the continent. So that this part of the trip might be enjoyed to the full, the steamer moored over night up the river and started the return trip early in the morning, reaching Quebec the second evening at supper time.

Among the more than half a hundred Summer Meeting attendants who went on the Saguenay River trip were Major E. G. E. Beaumont, H. L. F. Orcutt and H. S. Green, of the Institution of Automobile Engineers delegation, who made the trip as guests of the Society.

The Daily SAE

THE publishers and editors of *The Daily SAE* are to be congratulated on the four issues which they distributed in an endeavor to get the members started each day with a smile. The editorials à-la-Brisbane and the cartoons proved that one can never tell what is inside of a book by the cover. "Boy, page Mr. William Randolph Hearst!"

The excellently written news items covering all the activities were inter-

But The Public Really Pioneered

spersed with cartoons and humorous accounts of incidents, making a paper which was as welcome at the breakfast table as the very necessary cup of coffee. In other words, the *Daily SAE* was remarkably entertaining and enjoyed by all. A number of the cartoons are reproduced in this issue of THE JOURNAL, as well as a complete front page of one issue.

The Delco-Remy Corporation, the publishers, was fortunate in obtaining the services of such a staff as was provided by the Campbell-Ewald Co., the collaborators in this successful undertaking.

As succintly stated in the masthead of the *Daily SAE*, the staff was as follows:

C. E. Wilson—He pays the bills
"Bill" Moffett—He runs them up
Foust Childers—He sharpens pencils
"Milt" Morgan—He breaks them
"Dud" Carson—He fell on his head
"Eddie" Rothman—He is in reserve.

Members Hear French Folk Songs

AT the close of the Foreign Session, members and guests had the privilege of hearing the Chanteurs de St. Dominique in a concert of French humorous and folk songs. The concert was made possible by Past-President John H. Hunt, who heard the choir on a previous trip through the Province and had suggested that the concert be arranged for the Summer Meeting.

The concert was greatly appreciated by those present, especially the rendering of Alouette, the popular French-Canadian song which dates back over 700 years. Other songs which were greatly appreciated were Je Sais Bien Quelque Chose, Au Cabaret, Dans Tous les Cantons and L'ane de Jean. The choir was managed by M. Auréle Leclerc and the singing directed by M. Tolber.

The Chanteurs de St. Dominique were introduced at the close of the Foreign Session by Meetings Committee Chairman John A. C. Warner in the following well-chosen words:

Messieurs et dames, c'est avec le plus grand plaisir que je presente Messeurs les Canteurs de St. Dominique. Ces artistes distinguès rendront des chansons de leur poys magnifique.

Shea Swims to Victory

Wins Golf Championship in Tournament at Quebec Golf Club

Il est du devoir de chaque joueur de Golf de remplacer le gazon.

CETTE RÈGLE DOIT ÊTRE OBSERVÉE.

A NEW golf champion was crowned at the Quebec meeting. Not only was J. B. Shea the winner of the Championship Flight by a final victory of four up and three to play over Merl Wolfard, the runner-up, but he also was the medalist, with a score of 84 in the qualifying round.

A. W. Anderson, the defending champion, got as far as the second round by defeating W. M. Horton five and four, but lost to Shea two and one. Howard Kinnear had reached the third round and gave Shea his hardest battle, finally losing on the 18th hole.

Wolfard, who met Shea in the finals, had to meet G. H. Ralls, the 1925 champion, who had qualified with the second lowest score, 85, in an early round. Sanford Brown, the 1926 champion, was defeated by McDuffee, who in turn was defeated by Wolfard.

Wolfard got his revenge in the driving contest, however, in which he took first place, Jack Munjar taking second, and K. T. Brown third place.

The score-card for the championship flight was as follows:

CHAMPIONSHIP FLIGHT

J. B. Shea, 84 H. M. Crane, 90	Shea default	Shea 2 up	Shea 1 up	Shea 4 up
A. W. Anderson, 88 W. M. Horton, 92	Anderson 5 up			
C. H. Foster, 86 H. Kinnear, 91	Kinnear 2 up	Kinnear 5 up		
J. W. Bryant, 89 J. Funk, 92	Bryant 1 up			
G. H. Ralls, 85 M. Wolfard, 90	Wolfard 4 up	Wolfard default	Wolfard 2 up	
R. R. Braggins, 88 F. A. Thompson, 92	Default			
J. H. McDuffee, 88 S. Brown, 91	McDuffee 4 up	McDuffee 2 up		
T. H. Bourke, 89 W. V. Isgrig	Bourke default			

On the basis of the Inter-Sectional Golf Championship decided upon by the

NEWS HOUNDS, KEY PUNCHERS AND FINANCIER OF THE DAILY SAE

Left to Right—"Dud" Carson, "Bill" Moffett, C. E. Wilson, President, Delco-Remy Corporation, Foust Childers and "Milt" Morgan, Whose Good Humor and Untiring Efforts Afforded Excellent Breakfast-Table Entertainment

STRICKLAND WINS

THE DAILY SAE

QUEBEC, P. Q., CANADA, FRIDAY, JUNE 29, 1928

EXTRA

Do Not Forget Your Return Transportation
—Delco-Remy Corp. Publishers

COLORFUL BALL ENDS SESSIONS

Crowning Social Event of Quebec Gathering Is Dance Last Night in Chateau

Another Grand Ball has passed into S. A. E. history.

Last night's affair, held in the grand ballroom of the Chateau Frontenac, was a colorful and sparkling event, fully meeting the standards established by its predecessors.

Possibly, due to the fact that the locale was within the more liberal confines of Quebec, the grand ball was even snappier than the balls of yesteryear.

Alluring Gowns

The ladies were there in brilliant and alluring decollete. Their gowns made a shifting kaleidoscope of the dance floor. They were squired by sombre-garbed but fast-stepping escorts who donned formal attire for the crowning social event of the 1928 Summer Session. But that didn't make it a formal party. Quite the contrary.

The president of the Society of Automotive Engineers led the informality by sliding expertly out on the floor and cutting in with 100 per cent assurance and success.

That, probably, is what set the 1928 grand ball apart—it was a formal party without the slightest trace of formality.

Ye Gods, What a Shot Murray Made!

Claude Murray of Chicago is to receive two leather medals from the Kent Golf Club for two remarkable achievements—one for making a hole in one yesterday afternoon and the second and larger medal for making the hole in one on a green other than the one he was shooting for.

Murray was one of a mixed foursome—one of the Micks being named Brennan—while the other two were Carl Oesterman and Miss Helen Nightingale.

On the 18th tee, Murray made a mighty swipe and got a mighty slice—the ball shooting off at a tangent and landing in the hole of the 5th putting green. The foursome ended in an argument on a fine point of golf as to whether he now belongs to the Hole-in-One Club.

Want Daily Sae Copies?

Those who wish a complete file of the four issues of The Daily Sae printed during the 1928 Summer Meeting, may obtain them by writing the Delco-Remy Corp., Anderson, Indiana, publishers.

You Can't Be Mean To 'Seeck' Horse--No Siree!

W. F. Jennings of the Metropolitan Section who has never been in a motor car accident though he claims to drive 50 miles per hour on good state highways, came all the way to Quebec to get thrown from a jaunting cart. Beg pardon—the name of the vehicle is Calèche—two wheels, both big, and a horse, not so big.

In attempting to get real atmosphere he choose a Calèche for perfect transmission—it transmits every shock of the road to you unimpaired. And then he whizzed along—the wind only catching up with him occasionally. All of six miles an hour. This is the life, he thought, if you have the constitution.

The One Horse Power in front didn't look any too strong. But then it might be one of those wiry steeds that look half starved, he thought, but is actually a bear for punishment.

But a-a-ah. First thoughts are apt to be correct. Suddenly the horse's legs grew boneless. Down he went. Jennings shot over the buckboard.

As he brushed himself off and glowered at the cabby, the latter diagnosed, in a flash, the situation. "Him seeck", he called out, bright-eyed, with the air of a Columbus discovering America. Jennings glowered again—oh, a dirty glower.

WILLIAM R. STRICKLAND IS NOMINATED PRESIDENT OF S.A.E. FOR YEAR 1929

William R. Strickland

Hon. E. P. Warner, Assistant Secretary of Navy, Is Given Nomination As First Vice-President of the Society—Committee Reports at Ball

W. R. Strickland, Detroit, assistant chief engineer of the Cadillac Motor Car Company, is the 1929 nominee for president of the Society of Automotive Engineers it was announced last night at the annual grand ball.

Mr. Strickland, now first vice-president of the Society, and chairman of the current technical program committee, has long been a prominent figure in the automotive industry. His S. A. E. activities include membership during 1925-26-27 in the ball and roller bearings division, and the chairmanship in 1925 of the Detroit Section and of the ball bearings sectional committee, A.E.S.C.

Warner First V. P.

The nominee for vice-president in 1929 is the Hon. E. P. Warner, assistant secretary of the Navy in charge of aviation. He has been exceptionally prominent in S. A. E. affairs, the long list of his services including the chairmanship of the aeronautic division during 1926 and 1927.

The second vice-presidents nominated are:

O. C. Berry, motor car engineering.
E. N. Sawyer, tractor engineering.
Victor W. Kliesrath, marine engineering.
J. B. Fisher, stationary internal combustion engineering.

New Councilors

W. T. Fishleigh, James A. Moyer and Orrel A. Parker were nominated councilors for 1929-1930, the present 1928-1929 councilors being E. W. Templin, J. W. White and F. G. Whittington. C. B. Whittelsey is again nominated treasurer.

The nominations have been accepted by the candidates, and the balloting will be conducted by mail with the results announced formally at the next New York Automobile Show.

B. B. Bachman is chairman of the nominating committee.

ARCHERY FINALS

The final flight in the ladies' archery contest will be shot at 10 a. m. today, it is announced by Charles Hollerith, archery chairman.

X Marks Spot Victim Hit

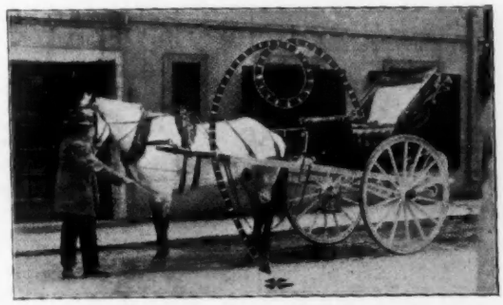


Photo - diagram shows Jennings' parabola just as he described it.

HE HEARD 'EM

"Do you hear the beautiful chimes, Mr. Sergardi?"

"What?"

"Do you hear the music of the chimes?"

"Talk louder. Those d—church bells are making so much noise."

Golf Committee, J. B. Shea scored 100 points for Cleveland Section and Merl Wolfard scored 50 points for the New England Section.

In the first flight of the Inter-Section Championship, W. S. Harley and J. R. Frantz scored 100 points by winning the flight, and Louis Schwab and Knox Brown, the runners-up, scored 50 points for the New England Section. The scores for the first flight were as follows:

Beck and Coleman, of the Pennsylvania Section, defeated Bijur and Reeves, of the Metropolitan Section.

Schwab and Brown, of the New England Section, defeated Beck and Coleman, of the Pennsylvania Section, 2 up.

Harley and Frantz, of the Milwaukee Section, defeated Wooler and Wales, of the Cleveland Section, 4 up.

Williams and Hunter, of the Indiana Section, defeated Hall and Slaght, of the Buffalo Section, 10 up and 7 to play.

Harley and Frantz defeated Williams and Hunter, 3 up.

Harley and Frantz defeated Schwab and Brown, 1 up.

In the Second Inter-Section Flight, H. D. Hukill and G. Waters won, scoring 80 points for the Cleveland Section, Wright and Nelson, the runners-up, scoring 40 points for the New England Section.

Chase and Reinhard won the third Inter-Section Flight, scoring 60 points

CHAIRMEN OF THE SPORTS COMMITTEES AND SOME OF THE CHAMPIONS

Cap Risley, Chairman of the Golf Committee, at Left, and Dale S. Cole, Chairman of the Tennis Committee, at the Right. At the Upper Left Appear the Four Golf Finalists; Left to Right They Are H. Kinnear, Defeated by Shea; J. H. McDuffee, Defeated by Wolfard; M. Wolfard, Defeated by Shea; and J. B. Shea, the 1928 S.A.E. Golf Champion. At the Upper Right Are the Tennis Experts Who Survived Early Elimination; They Are Alfred Reeves, Jr., J. Nikonow, C. H. Kindl and Herbert Chase

WINNERS OF THE LADIES' TENNIS TOURNAMENT AND RUNNER-UP IN THE GOLF TOURNAMENT

Mrs. C. T. Klug (Right), Who Won the Ladies' Tennis Tournament by Defeating Mrs. Herbert Chase (Left). Mrs. Stanley Whitworth (Center), Who Was Defeated in the Ladies' Golf Championship by One Stroke and Came Back with a 95 on the Second Day

for the Metropolitan Section. Parker and Figge, the runners-up of this flight, scored 30 points for the Cleveland Section.

According to the scoring decided upon for the Inter-Section Golf Championship, the trophy went to the Cleveland Section, with a total score of 210.

The two-ball mixed-foursome was a lively affair, but was cut short by a cloudburst at the completion of nine holes. Because of the condition of the course following this downpour, the play could not be resumed, so this match was decided according to the number of holes that had been completed. Mrs. J. K. Frantz and Dalton Risley, Jr., were the winning team.

Mrs. Frantz won the Ladies' Golf Championship with a medal score of 104, Mrs. Stanley Whitworth taking second place with a score of 105.

Great credit is due to Cap. Risley and Sandy Brown, who worked under tremendous difficulties in running off the S.A.E. events at the Quebec Golf Club and the Kent Golf Club. The courses were a mile apart, the Kent course being at Montmorency Falls, nearly 8 miles from the Chateau. Special bus service was arranged for the convenience of the golfers, but the distant location of the golf courses made it difficult to conduct the tournaments. The 19th hole was incomparable, and the excellent service at the clubhouse made up for the poor putting greens, which had been partly killed by the severe winter.

Nearly 200 golfers played in the qualifying round, the last of them coming in after dark. Rain interfered with the events on Wednesday and Thursday; those who played through the rain should be commended for their bravery.

The Golf Committee recommends that next year 18 holes of Medal Play be used as a qualifying round, as this year, to be followed by 36 holes of Medal Play to decide the different champions.

One of the features of golf in Quebec was that the caddies could not answer back when strong English was used, the angelic look on their faces as the members expressed their thoughts turning away a great deal of wrath.

Tennis Championship Still in Doubt

TENNIS as an S.A.E. sport again came into its own at the courts of the Boischatel Golf Club. Although the many showers occurring during the Convention prevented continuous playing, the courts dried quickly enough to permit the running off of all of the matches except the final match between Herbert Chase and J. P. Nikonow. This match is to be played off in New York City early in July, and the winner will be announced in the August issue of THE JOURNAL. In addition to playing at the Boischatel Club, members also played at the Quebec Tennis Club, within a few minutes' walk of the Chateau.

Herbert Chase and C. H. Kindl won the Doubles Championship by defeating Burt Lemon and K. Brandenburg in the final match. Mrs. Klug won the Ladies' Singles Tournament, defeating Mrs. Herbert Chase in the final match. The complete scores for the tournaments are as follows:

MEN'S DOUBLES CHAMPIONSHIP

First Round.—Lemon and Brandenburg defeated Abell and Curtis 6-4, 6-1; Hadaway and Klug defeated Vogeler and Vogeler 6-1, 6-3; Chase and Kindl defeated Green and Cole 6-2, 6-3.

Semi-Finals.—Lemon and Brandenburg defeated Hadaway and Klug 4-6, 6-4, 6-3; Chase and Kindl defeated Reeves and Nikonow 7-5, 6-3.

Final.—Chase and Kindl defeated Lemon and Brandenburg 7-5, 6-3.

MEN'S SINGLES CHAMPIONSHIP

First Round.—R. M. Curts defeated F. M. Thomson; K. Brandenburg defeated H. S. Green; Alfred Reeves, Jr., defeated Rollin Abell.

Semi-Final Round.—Herbert Chase defeated Burt Lemon 6-3, 6-0; J. Nikonow defeated Alfred Reeves, Jr., 6-1, 6-1.

Final.—To be played off in New York City by Herbert Chase and J. P. Nikonow.

Quebec Bridge Popular

AMONG other records broken by the unusual Summer Meeting of 1928 was that for the attendance of ladies, the wives, daughters and sisters of S.A.E. members.

While sightseeing, golf, tennis and other sports claimed much of their attention, the indoor entertainment provided—bridge—received its share of interest. Ladies' daytime bridge parties were arranged for Wednesday, Thursday and Friday, and, by way of vari-

ety, mixed bridge for Wednesday evening. First, second and third prizes were awarded for each session's high score and for the three highest scores in any one session, and nine awards were made each day for players having scores from the fourth to the twelfth highest.

Those whom skill and fortune favored for the prizes for the best of four sessions' play were Mr. R. M. Curts, first; Mrs. G. W. Hobbs, second; and Mrs. G. N. Limeburner, third; with scores of 2531, 2116 and 2006, respectively, made in the play Wednesday evening. The players having the 12 highest scores for each of the other three individual sessions of play, together with the scores, are as follows:

Wednesday afternoon, Mrs. V. C. Cramer, 1988; Miss Jessie Owen, 1951; Mrs. F. W. Parks, 1750; Mrs. J. J. Balsom, 1747; Mrs. A. E. Bronson, 1700; Mrs. C. M. Kaltwasser, 1619; Miss Elsie Wine, 1539; Mrs. Fred Cornell, 1531; Mrs. J. Hughel, 1495; Mrs. W. A. Baker, 1494; Mrs. F. M. Germane, 1429; and Mrs. R. M. Owen, 1395.

Thursday afternoon, Miss Jessie Owen, 1502; Mrs. R. M. Owen, 1473; Mrs. F. W. Marschner, 1332; Mrs. V. W. Kleisrath, 1312; Mrs. G. E. Strohm, 1289; Mrs. M. H. Cox, 1281; Mrs. F. J. Lane, 1250; Mrs. W. S. Harley, 1205; Mrs. H. A. Hansen, 1162; Mrs. E. H. Janes, 1099; Mrs. Fred Cornell, 1094; and Mrs. G. W. Hobbs, 1094.

Friday forenoon, Mrs. G. E. Strohm, 1538; Mrs. Fred Cornell, 1419; Mrs. F. J. Lane, 1304; Mrs. Guy Motz, 1301; Mrs. R. E. Helferich, 1176; Mrs. F. W. Parks, 1023; Mrs. Fuller, 961; Mrs. Carl Kindl, 894; Mrs. A. S. Van Halteren, 862; Mrs. J. Hughel, 734; Mrs. B. M. Smarr, 727; and Mrs. F. Prescott, 559.

An arrow Episode

THIS year's Summer Meeting presented an innovation in the form of the Men's Archery Tournament. Of course the Ladies' Tournament was held as usual. In order that there should be no casualties, the men were required to shoot at a different time than their wives. The interest shown, however, apparently justifies the decision of the Committee to continue men's archery as one of the Summer Meeting sports.

Those who searched for Moses in the bullrushes had nothing on the archery contestants who attempted to find their arrows after once shot. However, with the aid of a good steam-heated French lawn-mower, the long grass was cleared away sufficiently to enable the fair and other contestants to discover what had happened to their arrows after they left the bow. From this it will be gathered that many of them hit the target.

Events were held on the morning and afternoon each day, and in view of the scores made, prizes will be awarded for the high score each day as well as to the winners of the finals on the last day. The box score for the entire tournament is given herewith:

Wednesday.—L. C. Fuller, 16; F. E. Booth, 13; L. E. Lighton, 7; Jack Gray, 6; H. L. Towle, 6.

Thursday Morning.—Ladies: Jeanette Anglada, 56; Alice Brown, 11; Doris Brown, 11; Jane Schwarz, 4. Men: W. M. Horton, 33; H. L. Towle, 30; L. C. Fuller, 29; W. F. Rockwell, 2.

Thursday Afternoon.—June Nightingale, 10; G. E. Platzer, 3.

Friday Morning Finals.—Ladies: Mrs. McGrath, 17; Jeanette Anglada, 10; Mrs. Walthers, 4; Alice Brown, 0; Doris Brown, 0. Men: L. E. Lighton, 21; J. E. Hale, 13; N. MacCoull, 10; H. L. Towle, 9; G. E. Platzer, 2.

The Archery Contest was held, by special permission of the governmental authorities, in the moat of the citadel towering above the Chateau, the walls protecting the arrows from the strong wind prevailing a large part of the time. A stairway leading to the moat from Dufferin Terrace, which might conservatively be estimated at 200 steps, was doubtless responsible for the poor marksmanship shown by many of the contestants.

THE HON. EDWARD P. WARNER

Who Flew to Quebec from Washington in the Vought Corsair Seaplane in Low Visibility To Attend the Meeting

Prizes

OWING to the Canadian customs regulations, the prizes for the various events were taken to Quebec under bond, and exhibited in one of the display windows in the hotel lobby. They will be sent to the winners of the various events as soon as they are released from bond and returned to New York City. The prizes were made possible through the prize fund established by companies in the automotive industry early in 1927.

The Grand Ball

A BACHELOR attending the Grand Ball, on the evening of Thursday, June 28, said that all the ladies there were wearing pink dresses. He was wrong. He may be a very good automotive engineer, but he evidently works under the handicap of almost total color-blindness. To mention only a few of the colors worn at the Grand Ball, it may be stated that there were gowns of the following hues: crimson, magenta, rose, burnt orange, henna, red, purple, cerise, yellow, canary, green, turquoise, powder-blue, lavender, lilac, orchid, violet, amethyst, gold, silver and (oh, yes) pink. The men showed more uniformity in their clothes, being attired in what is frequently spoken of as the conventional black.

The clothes were the only formal feature of the occasion. Apparently everyone knew everyone else (why shouldn't they?) and the "good time" that the only English newspaper in Quebec reported as "had by all" was a merry reality in this case.

According to custom, the report of the Nominating Committee was read at the ball. B. B. Bachman, chairman of the Nominating Committee, made the necessary announcements and introduced W. R. Strickland, the choice of the committee for President of the Society next year. Mr. Strickland expressed his appreciation in a few words and proceeded to endear himself to the hearts of his constituents there present by saying "On with the dance!"

The technique of dancing was then vivaciously demonstrated by a great number of couples to a large assemblage of interested spectators who did not choose to participate actively in this form of enjoyment, and a buffet supper was served at midnight to refresh the dancers and the onlookers.

The Summer Meeting Committees

THE success of the 1928 Summer Meeting depended entirely on the members of the various committees responsible for planning and running the meeting.

John A. C. Warner, as Chairman of the Meetings Committee, was responsible for the general program. W. R. Strickland, chairman of the Technical Program Committee, made possible the excellent technical program. The golf tournaments were ably handled by Cap Risley, Chairman of the Golf Committee. Under the chairmanship of Dale Cole, the Tennis Committee was responsible for bringing tennis back as one of the major sports at the Summer Meeting. Charles Hollerith and L. A. Chaminade, in charge of the archery, should be congratulated for putting over a successful Men's Archery Tournament, an event which is sure to be continued as one of the regular Summer Meeting activities. C. T. Klug and Beulah Brede were responsible for the bridge parties held in the Riverview Lounge which, as the name indicates, afforded a commanding view of the St. Lawrence.

A. S. McArthur, responsible for the sightseeing trips held during the Convention, deserves a great deal of credit for the wonderful way in which the trips to Old Quebec, Montmorency Falls and Sté. Anne de Beaupré were arranged and handled.

Fay Chandler, Chairman of the Country Fair Committee, should receive honorable mention for the most interesting novel feature ever held at recent S.A.E. Summer Meetings.

The complete Summer Meeting Committee personnel is as follows:

S. A. E. MEETINGS COMMITTEE
J. A. C. WARNER, *Chairman*
E. P. BLANCHARD
S. R. DRESSER
A. W. S. HERRINGTON
L. C. HILL
F. C. HORNER
G. L. MARTIN
G. L. MCCAIN
C. A. MUSSELMAN
W. R. STRICKLAND
J. F. WINCHESTER
H. T. WOOLSON

SUMMER MEETING TECHNICAL PROGRAM COMMITTEE
W. R. STRICKLAND, *Chairman*
F. K. GLYNN
A. W. S. HERRINGTON
L. C. HILL
G. L. MCCAIN
H. L. TOWLE
H. T. WOOLSON

GOLF COMMITTEE
DALTON RISLEY, JR., *Chairman*
SANFORD BROWN

TENNIS COMMITTEE
DALE S. COLE, *Chairman*
T. N. BOURKE
B. J. LEMON
J. P. NIKONOW

ARCHERY COMMITTEE
CHARLES HOLLERITH, *Chairman*
L. A. CHAMINADE

GRAND BALL COMMITTEE
J. G. SWAIN, *Chairman*

BRIDGE COMMITTEE
C. T. KLUG, *Chairman*
BEULAH BREDE

ENTERTAINMENT COMMITTEE
EDGE AUSTIN, *Chairman*

MOTION PICTURE COMMITTEE
D. E. GAMBLE, *Chairman*
SANFORD BROWN
R. J. NIGHTINGALE

I. A. E. RECEPTION COMMITTEE
JOHN H. HUNT, *Chairman*
S. R. DRESSER
W. T. FISHLEIGH
G. L. MCCAIN
W. R. STRICKLAND
J. G. VINCENT
J. A. C. WARNER
H. T. WOOLSON

SIGHTSEEING COMMITTEE
A. S. MCARTHUR, *Chairman*

COUNTRY FAIR COMMITTEE
FAY CHANDLER, *Chairman*
SANDY BROWN
A. K. BRUMBAUGH
ALBERT LODGE

PROMINENT PRESENT AND FUTURE OFFICERS OF THE SOCIETY

W. R. Strickland (Left), First Vice-President and Presidential Nominee for 1929; President W. G. Wall (Center); Edward P. Warner (Right), Nominee for First Vice-President for 1929

Committees Recommend Radical Changes

Reorganization of Society To Be Studied

AS a result of the various suggestions regarding changes in the Society Constitution, a general conference was held on Thursday during the Summer Meeting, at the request of President Wall, at which the Society organization was discussed in detail. As a result of this discussion, it was the consensus of opinion that there was an unquestionable need for a careful analysis of the organization of the Society looking toward a possible reorganization on the basis of professional interest.

The Conference was presided over by F. E. Moskovics, chairman of the Constitution Committee, other members present being J. C. Chase of the Constitution Committee, President Wall, W. T. Fishleigh, H. M. Crane, W. N. Davis, F. C. Horner, A. L. Lodge, H. L. Towle, V. G. Apple, John Younger, Earle Buckingham, F. F. Chandler, A. L. Pope, S. R. Dresser, Secretary Coker F. Clarkson and C. E. Heywood of the Meetings and Sections Department.

The situation was well stated by W. T. Fishleigh, past-chairman of the Detroit Section, who said that it was time for fundamental and radical changes in the Constitution of the Society, it being most illogical for the Second Vice-Presidents representing the various fields to have no specified duties, all Society professional activities being handled through general committees.

At the close of the Conference, it was understood that President Wall would appoint a Reorganization Committee of seven members to study the information that has been collected, the members of the Constitution Committee to serve on the Reorganization Committee so that if any changes are necessary in the Constitution, they will be in a position to make the necessary recommendations. In the opinion of John Younger, the work of this committee represents one of the most important projects before the Society.

Tire Simplification

AT a meeting held at the Chateau Frontenac, Quebec, on June 27, representatives of the tire companies, the National Automobile Chamber of Commerce, the Tire and Rim Association of America, Inc., and the Society discussed the advisability of establishing a more or less permanent informal committee of the automotive and the tire industries to guide future tire standardization. The meeting was led in the discussion by H. M. Crane, who outlined the framework of a committee of tire and motor-car engineers to bring about in due course further simplification in the number of sizes and control in the adoption of new sizes.

Alfred Reeves, of the National Automobile Chamber of Commerce, indicated that organization's approval of some such plan. The various representatives of the tire companies stated that the tire industry welcomed work along the lines of size simplification, and indicated that their cooperation could be counted upon to the fullest extent.

No decision was reached as to the personnel of such a committee. The present plans call for meetings of the proposed committee to be held quarterly, the first some time in the latter part of September and the second meeting during December, so that, should any action of the Standards Committee be required, it could then be taken at the Annual Meeting of the Society in January.

Should Include Heavy-Duty Tires

It was the consensus of opinion of those present that the work of any committee formed should be extended to include truck and motorcoach tires, as well as passenger-car tires, which might necessitate a special section of the committee to consider this phase of the subject. Details of the method of procedure will be decided after the organization is completed.

The function of the committee will be purely advisory, formal action on any recommendations being left to the National Automobile Chamber of Commerce, the Rubber Association of America, Inc., the Tire and Rim Association and the Standards Committee of the Society as heretofore.

Those who attended the meeting in Quebec are as follows:

R. D. Abbott, Miller Rubber Co.
E. Botts, U. S. Rubber Co.
A. E. Bronson, Dill Mfg. Co.
C. F. Clarkson, Society of Automotive Engineers, Inc.
H. M. Crane, General Motors Corporation
E. E. Dearth, Fisk Rubber Co.
W. T. Fishleigh, Ford Motor Co.
A. G. Geistert, Chevrolet Motor Co.
E. W. Griffith, Wire Wheel Corporation of America
W. R. Griswold, Packard Motor Car Co.
J. E. Hale, Firestone Tire & Rubber Co.
K. L. Herrmann, Studebaker Corporation of America
W. G. Kearney, B. F. Goodrich Rubber Co.
G. C. R. Kuipper, Budd Wheel Co.
B. J. Lemon, United States Rubber Co.
Alfred Reeves, National Automobile Chamber of Commerce.
A. J. Scaife, The White Motor Co.
H. F. Schippel, B. F. Goodrich Rubber Co.
J. G. Swain, Firestone Tire & Rubber Co.
H. M. Taylor, Firestone Tire & Rubber Co.
J. C. Tuttle, Goodyear Tire & Rubber Co.
A. J. Underwood, Society of Automotive Engineers, Inc.
George Walther, Dayton Steel Foundry Co.

Proposes Increase in Society Dues

AT the meeting of the Sections Committee on Tuesday afternoon, the opening day of the Summer Meeting, the following resolution was adopted unanimously:

WHEREAS the Sections Committee believes that the Sections of the Society constitute one of the most important activities of the Society, and whereas all members in the United States, regardless of residence, share equally in the benefits derived from Section activities, both through meetings and papers published in the S.A.E. JOURNAL, and

WHEREAS we believe that segregated dues for National and Section membership is an inequitable means of supporting S.A.E. activities, therefore,

Be It Resolved that this Committee recommends to the Council that the necessary steps be taken to make the Section and National dues one charge of $20 against each member in the United States, $5 of this to be made available, if needed, to the nearest Section.

It was pointed out that 52 per cent of the Society members are now members of the various Sections, the increased dues affecting only 48 per cent of the membership, of which only two-thirds reside outside of Section territory.

It was also noted that the increase in Society dues would not be actually an increase for the 3500 members who now support the Sections; it would merely be a change in the bookkeeping, the Section monies being collected by the National Society as part of the National dues. The same procedure is followed by other National societies.

The resolution adopted by the Committee was drawn up by a Subcommittee consisting of W. T. Fishleigh, S. L. Bradley and S. R. Dresser, this committee having been appointed following a general discussion of the advantages and disadvantages of the proposed change. It is felt that the change will result in an increase in Society membership, as the Membership Committees of the various Sections will devote their energies to getting new Society members rather than trying to enlist the support of Society members in Section activities as in the past.

The Sections Committee also recommended to the Council that:

A reasonable entertainment expense be recognized on the same basis as printing and a limited number of complimentary dinner tickets, and that Sections of the Society be allowed an entertainment expense of 25 cents per

person attending a Section dinner, the total amount not to exceed $150 for any one meeting.

It was agreed that this recommendation was desirable, the present procedure for handling entertainment expense by Sections which are not self-supporting or which do not have advertising revenue being to obtain in advance the approval of the Council of the Society. Although there was a distinct difference of opinion as to the desirability of entertainment at Section meetings, it was recognized that this was a matter of opinion and that the recommendation should be adopted for the benefit of those Sections desiring to have entertainment features at their meetings.

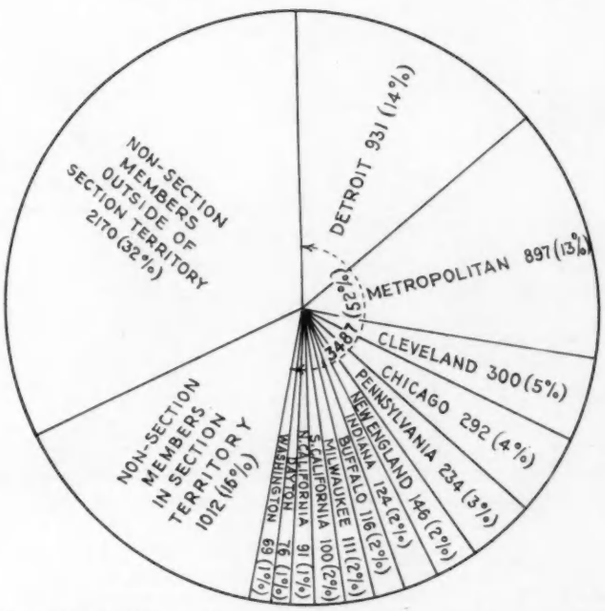
The Sections Committee also approved the adoption and distribution of a Sections Manual which had been compiled by the Sections Department, this Manual outlining in detail the inter-relationship of the Sections with the National Society. It was understood that the Manual would be put in permanent and convenient form, and distributed to all officers and committee members of the Sections.

The Sections Committee meeting was presided over by Chairman Vincent G. Apple, the members present representing the various Sections as follows: E. W. Kimball, Buffalo; R. E. Plimpton, Chicago; A. A. Skinner, A. K. Brumbaugh, John Younger, S. L. Bradley, Cleveland; B. J. Lemon, W. T. Fishleigh, F. W. Marchner and L. A. Chaminade, Detroit; F. H. Prescott, Indiana; E. F. Lowe and S. R. Dresser, Metropolitan; F. M. Young and H. L. Debbink, Milwaukee; Albert Lodge and W. M. Clark, New England.

Journal Size Proposed for Transactions

RECOMMENDATIONS which will be of particular interest to Society members were formulated at a meeting of the Publication Committee on Thursday morning during the Summer Meeting.

The first and possibly the most important change proposed in the Society publication policy during recent years was the recommendation to change the present 6 x 9-in. size of the TRANSACTIONS to the size used for THE JOURNAL. However, in order that this size of volume may fit in the average bookcase, it was proposed that the length of THE JOURNAL page be slightly reduced and narrower margins used for the TRANSACTIONS than for THE JOURNAL. This will result in an over-all size of volume of 8½ x 10½ in.



CLASSIFICATION OF SOCIETY MEMBERSHIP ON SECTION BASIS

The change as proposed will make it possible to eventually issue the TRANSACTIONS within 3 months after the publication of the last JOURNAL which a given volume of the TRANSACTIONS will cover. It will also make it possible to reproduce all illustrations as published in THE JOURNAL, no changes in make-up being necessary, as at the present time. The change will also reduce the cost of production of the TRANSACTIONS slightly. The change in the size of TRANSACTIONS was outlined in detail in the June issue of THE JOURNAL, p. 621.

The second recommendation of the Publication Committee is to compile a cumulative index covering the papers and discussions that have appeared in the S.A.E. BULLETIN, THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS, the S.A.E. JOURNAL and the TRANSACTIONS. These publications, covering a period of 20 years, contain a wealth of automotive engineering material which is available only through reference to the individual indexes of the many volumes.

The meeting was presided over by John Younger, chairman of the Publication Committee, and was attended by E. P. Warner, past-chairman, M. C. Horine, Norman G. Shidle, Secretary C. F. Clarkson, Charles E. Heywood and H. W. Perry of the Publication Department.

Aeronautic Meeting for New York City

AT the conference of the Meetings Committee members, held on Friday during the Summer Meeting, it was decided to hold an Aeronautic Operation Meeting in New York City during the week of the Annual Automobile Show, this Aeronautic Meeting to be in addition to the meetings in Los Angeles and Chicago.

Plans for the Los Angeles and Chicago Aeronautic Meetings, the Transportation Meeting, the Production Meeting, the Annual Meeting and the Annual Dinner were discussed in detail, reports either written or oral being submitted by the Chairmen of the various Technical Program Committees. Detailed information regarding these meetings will be published in early issues of THE JOURNAL. The dates for these meetings are given in the report of the Meetings Committee on p. 112 of this issue.

Replies received to Chairman Warner's letter, suggesting the desirability of scheduling papers dealing with the business problems involved in engineering, were discussed at length, it being generally agreed that it is very desirable to schedule such papers for the various National Meetings. It was also felt that matters of public interest such as legislation and traffic conditions should be considered at the several meetings, not only from the engineering viewpoint but from the business or administrative viewpoint.

The members also discussed the location for the 1929 Summer Meeting, possibilities mentioned being White Sulphur Springs, French Lick Springs, an ocean cruise, Spring Lake, and Atlantic City. No general agreement was reached.

Members of the Meetings Committee present at the meeting were Chairman John A. C. Warner, F. C. Horner, C. A. Musselman, J. F. Winchester and S. R. Dresser. Members present at the invitation of the Committee were H. M. Crane, J. H. Hunt, Albert Lodge, E. F. Lowe, Vincent Apple and E. S. Marks.

Standards Committee Reports Approved

THE regular session of the Standards Committee was held at 2 o'clock on Tuesday, June 26, with 44 members and guests present. Vice-Chairman W. R. Strickland presided in the absence of Chairman H. M. Crane, and the reports of the several divisions of the Standards Committee that were printed in the June issue of THE JOURNAL were presented by an officer or member of each of the respective divisions.

The reports, with such modifications as had been made by the divisions prior to the meeting, were approved, with the exception of the report of the Lubricants Division on a footnote for inclusion in the present S.A.E. Specification for Crankcase Lubricating-Oil Viscosity Numbers. This was referred back to the Division for further consideration.

A specification for taps for the 18-mm. spark-plug thread was included in the report of the Production Division, to be included with the other tap specifications that have already been adopted by the Society as a Production Standard.

All of the reports as approved by the Standards Committee were also approved, without further modification, by the Council of the Society at its meeting on Thursday, June 28, and by the adjourned Business Session of the Society on Thursday evening.

MODIFICATIONS TO BE PRINTED IN AUGUST

The most important modifications in reports were the elimination in the Aeronautic Division report on propeller-shaft ends of the eight-spline airplane propeller-hub shaft-end and the substituting for it a 16-spline shaft 1 in. shorter, and the addition of a still smaller spline shaft-end in this specification; omitting the G-10 series of electric incandescent electric lamps from the Lighting Division report on this subject; and substituting the part names for Body Parts Nomenclature that were given in the May issue of THE JOURNAL rather than those given in the June issue.

The detailed modifications of the reports that were printed in the June issue of THE JOURNAL, and the 18-mm. tap specification will be printed in full in the August issue, and the letter-ballot on final approval of the reports for adoption by the Society will be sent to the voting members of the Society. This ballot will be returnable and counted 30 days following publication of the August issue of THE JOURNAL. When the reports have been so approved, they will be published in HANDBOOK form and issued in a pamphlet that can be inserted in the 1928 edition of the S.A.E. HANDBOOK, inasmuch as the next regular edition of the HANDBOOK will not be published until March, 1929.

Research Committee Kept Busy

MEMBERS of the Research Committee and its subcommittees held a full schedule of meetings to review the progress of an active six months' furthering of the research projects of the Society.

Under the leadership of Chairman H. M. Crane, the Headlight Subcommittee and others interested in headlighting, to the number of about 20, met Wednesday morning for breakfast. H. H. Allen, of the Bureau of Standards, presented a report of the investigation into night-driving illumination being made under the technical direction of the Research Committee with funds provided by the National Automobile Chamber of Commerce. Plans were made for submitting the results arrived at to a larger number of observers.

Chairman R. W. Brown presided over the well-attended meeting of the Riding-Qualities Subcommittee held Wednesday at luncheon. The Subcommittee on Wheel Alignment met jointly with the riding-qualities group, and B. J. Lemon presented on behalf of its chairman, Prof. J. M. Nickelsen, a progress report of its activities since its formation as a result of action taken at the January meeting of the Research Committee. Plans looking toward the carrying out of riding-qualities research at Ohio State University were considered, and Tore Franzen and E. W. Stewart, who, with Dr. Benjamin Liebowitz, represent the Society on the Special Research Committee on Mechanical Springs of the American Society of Mechanical Engineers, spoke of the plans and aims of that body.

The Fuels Subcommittee came together at luncheon Thursday for a long session, with Chairman H. L. Horning leading the discussion. The Fuels Subcommittee represents the Society on the Cooperative Fuel Research Steering Committee, the other organizations interested being the National Automobile Chamber of Commerce and the American Petroleum Institute. The topics discussed were for the most part the projects being carried out by the cooperative research, including an engine designed to meet the need for a rugged and inexpensive device for the measurement of detonation that may be generally acceptable, the results of a detonation survey, of a study of the volatility measurements of gasoline and of investigation into engine acceleration.

Chairman B. B. Bachman called the Highways Subcommittee together at 5 o'clock Thursday afternoon to discuss the Cooperative Motor-Truck Impact Tests being carried out by the Bureau of Public Roads, the other interested organization being the Rubber Association of America.

The final meeting, that of the Research Committee held Friday morning at breakfast under the chairmanship of Dr. H. C. Dickinson, reviewed the work of the subcommittees, heard a report for the Research Department, and received suggestions for new research projects.

MANAGING TRIUMVIRATE OF THE AUTOMOTIVE INDUSTRY DISCUSSING CONDITIONS

M. L. Hemingway, General Manager of the Motor & Accessories Manufacturers Association; Coker F. Clarkson, Secretary and General Manager of the Society; and Alfred Reeves, General Manager of the National Automobile Chamber of Commerce

Full Program of Technical Sessions

Many Meritorious Papers and Much Written Discussion on New Developments Presented

NINE technical sessions and numerous meetings of the Council and various committees made a busy 4 days for the officers, committee chairmen, committee members, the speakers, and members of the Society who attended the sessions. Attendance at the technical sessions was subnormal for a Summer Meeting, a fact that attested to the attractions of Quebec as a summer resort and sightseeing mecca.

The General and Business Session on the first night, the Chassis Session on Wednesday forenoon, and the Foreign Session on Wednesday night drew fairly good attendance and also elicited much animated discussion of the subjects presented, which included the psychology of the engineer with relation to the business side of the automotive industry, spring suspension of automobiles, means of increasing the power output of a given engine, and brake legislation.

All of the score of papers were of real merit and dealt with uptodate subjects regarding new developments. A number were of much popular interest and drew a considerable sprinkling of ladies through the audience. An unusual amount of written discussion was submitted and this was available in mimeograph form, together with preprints of the papers, at the beginning of each session.

Condensed accounts covering the main points in the papers and discussion presented at the various sessions follows. In accordance with the practice of the Society, the papers of major technical value which do not appear in this issue of THE JOURNAL will be printed in early subsequent issues, together with the discussion on them.

I. A. E. Representatives Active in Sessions

WITH the first Summer Meeting of the Society ever held on foreign soil, it was only logical for the meeting to have an International aspect, especially in view of the delegation from the Institution of Automobile Engineers, headed by President E. G. E. Beaumont.

With Major Beaumont were H. S. Green, H. L. F. Orcutt, Roger Hall, T. Powell, and Capt. A. C. Burgoine. The Canadian automotive industry was also well represented, among these representatives being H. A. Brown, of the General Motors Corporation of Canada, who addressed the Foreign Session, and A. S. McArthur of the Toronto Transportation Commission, who was Chairman of the Sightseeing Committee.

The attendance of representatives of the I. A. E. at the Summer Meeting made it possible for an I. A. E. Dinner to be held on Wednesday evening, the members of the Institution being invited. The Dinner was presided over by John Younger. In addition to the foreign guests of honor and President Wall and Secretary Clarkson, B. B. Bachman, J. H. Hunt, W. R. Strickland and Ernest Wooler, who are members of the I.A.E., attended.

The Society owes a debt of gratitude to the members of the I.A.E. who were in a large measure responsible for the interesting papers and discussions at the various technical sessions.

What Ails the Engineer?

Inferiority Complex, Says Shidle—President Wall and Major Beaumont Review Practice

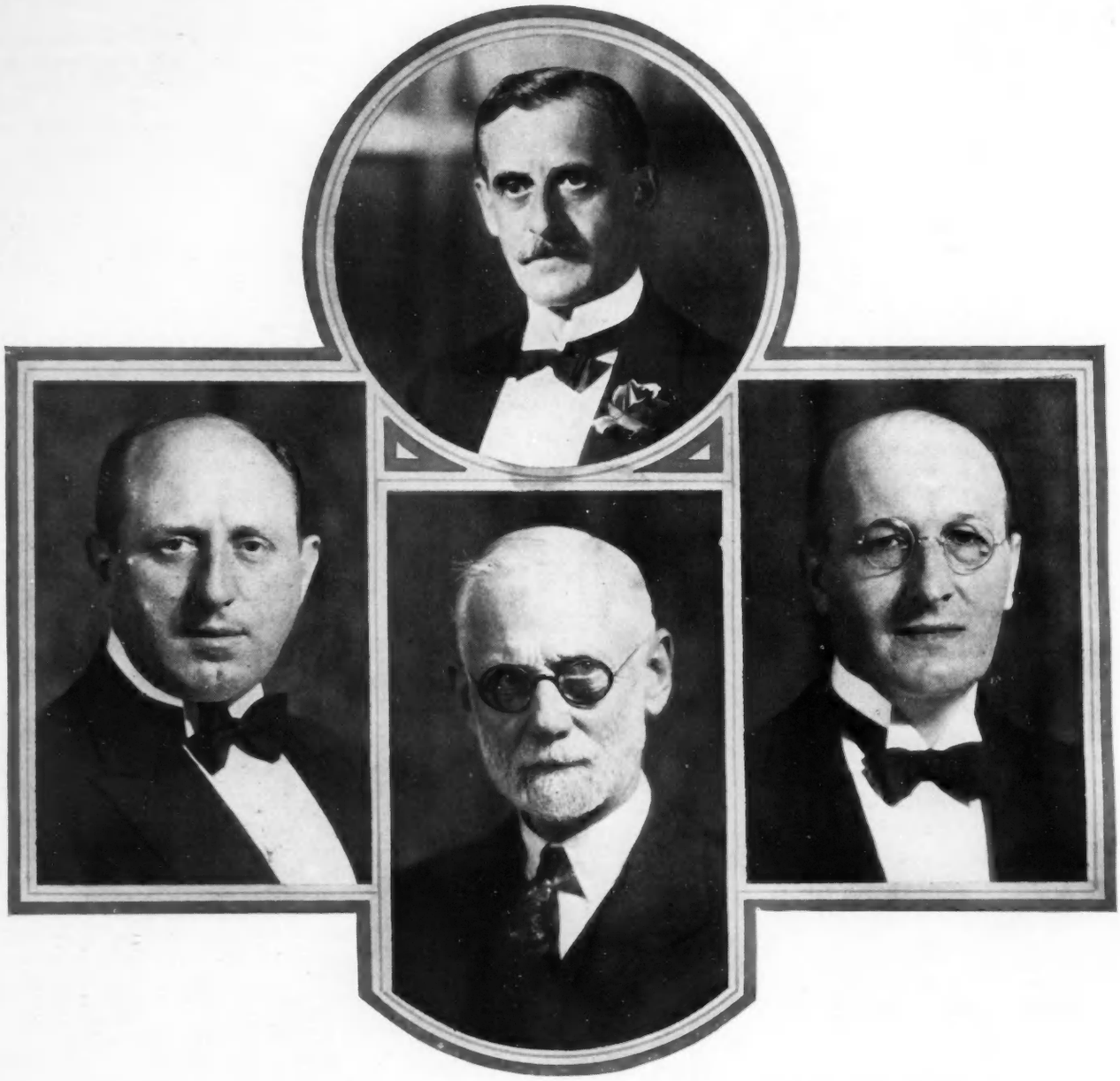
THE technical sessions got away to a good start with an attendance of about 200 in the Jacques Cartier room Tuesday evening following a very brief business meeting at which the administrative and technical committee reports of the Society were adopted by vote as printed in this issue of THE JOURNAL. President Wall presided and called upon the chairmen of the various committees to rise as he referred to the respective reports. As no new business was brought up, the business meeting was adjourned until Thursday, pending action of the Council on the standards reports.

YEAR'S ENGINEERING PROGRESS SKETCHED

President Wall, in his presidential address, then welcomed the English representatives of the Institution of Automobile Engineers, which he said had not been represented officially at a meeting of the Society for 15 years. In introducing Major E. G. E. Beaumont, president of the Institution, he said that the Society had gained a new member during the day, when the application of Major Beaumont had been acted upon, whereupon the audience broke into applause. The selection of Quebec as the place for the Summer Meeting was a happy inspiration, he said. Then he reviewed briefly the new engineering developments and progress made during the last year, mentioning the trend toward increased speed, acceleration, ease of operation and comfort in motor-cars; means adopted for increasing the power output of engines, such as freer flow of the mixture through the manifold, lighter reciprocating parts, better cooling around the valves and better design of the combustion-chamber. In the field of research he referred to development work in front-wheel drive, the steam motorcoach, the light Diesel engine, supercharging, hydraulic valve-gear, and new methods of damping vibration. Automotive engineers have never been so busy, he asserted, and, although much effort is spent in lowering the cost of production, the opportunities for the engineer possessing original and practical ideas never were greater.

Partly as the result of the stimulus given by the spectacular flights of Lindbergh, Byrd, Chamberlin, Fitzmaurice, and others, great advance has been made in aeronautics, and airplane factories are starting up all over the United States. The metal airplane is beginning to predominate, the monoplane is coming back into favor, and a remarkable change of front has occurred with regard to the air-cooled engine within the last 2 years.

The Society is particularly interested, declared President Wall, in the engineering side of the operation and maintenance of motor-vehicles and airplanes and is endeavoring to make its activities as attractive as possible to members who have graduated into the field of work. He can foresee



BRITISH DELEGATION FROM THE INSTITUTION OF AUTOMOBILE ENGINEERS WHO ATTENDED THE MEETING

Major E. G. E. Beaumont (Top), President of the Institution, Who Addressed the General Session, Gave His Own Paper on Cooperation in Transport at the Transportation Session, and Presented Maurice Platt's Paper at the Foreign Session. H. L. F. Orcutt (Bottom), Who Gave a Paper on Ground Gears and Transmission Design at the Transmission-Production Session. H. S. Green (Left) and Capt. A. C. Burgoine (Right), the Two Other Official Delegates

time, he said, when operation and maintenance will be the largest part of automotive engineering.

An endeavor is being made also to make the Society more attractive to the production engineer, who is the main factor in the economic manufacture of motor-vehicles today, said Mr. Wall; and also to the motorboat engineers, and to get the latter interested especially in standardization work.

The Society has come a long way in [illegible] years and the only danger he sees [illegible]n whatever tendency may exist to go outside of its chosen field. It is fundamentally an engineering organization but is working on a broad plane, as the word "automotive" is very comprehensive, and, while the Society must stay within the confines of automotive engineering, this can be interpreted in the broadest sense.

AMERICAN AND ENGLISH PRACTICE COMPARED

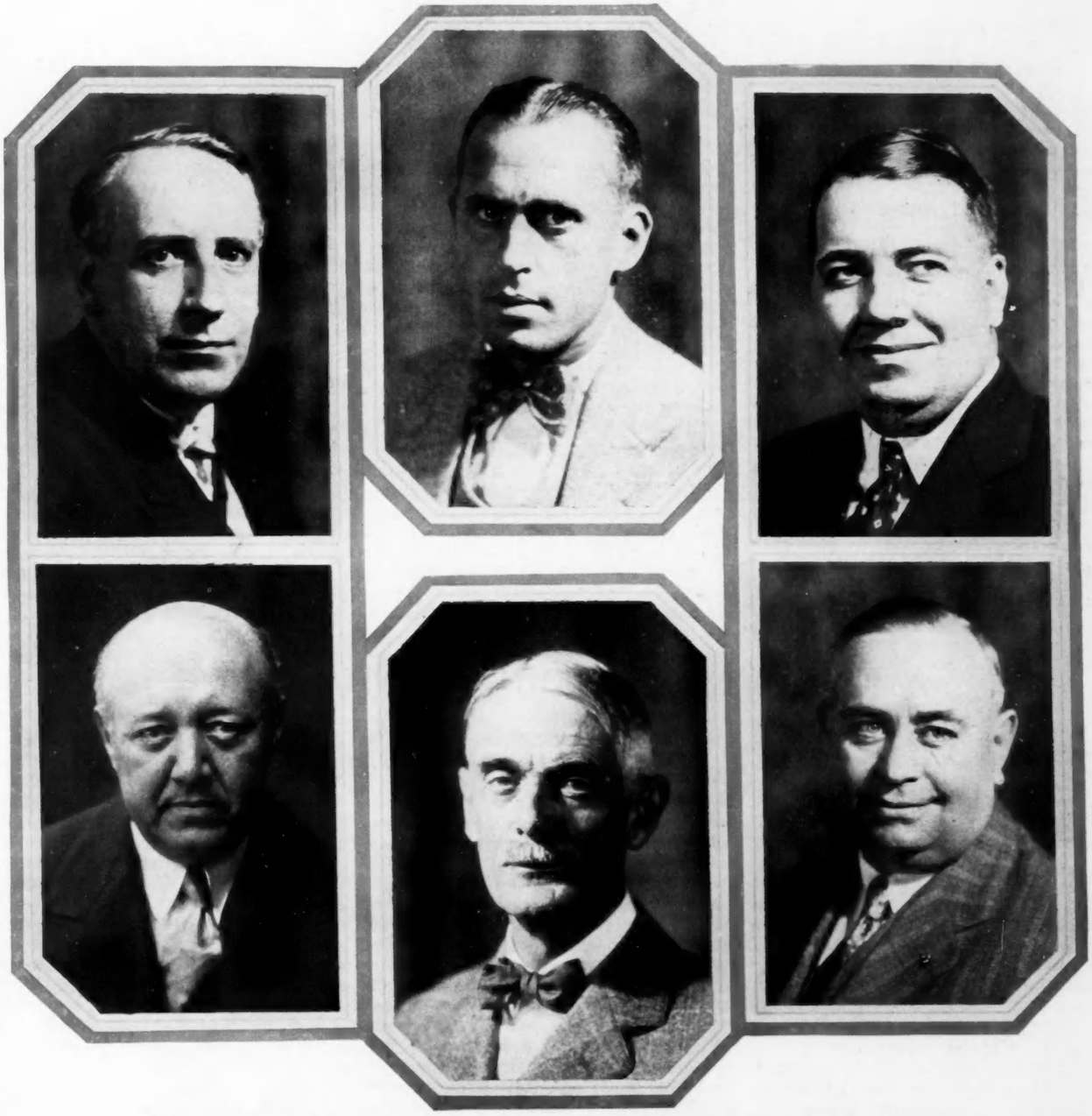
Major Beaumont, after conveying to the officers and members of the Society the greetings of the British Institution, spoke on the European viewpoint on automobile engineering problems and compared and contrasted the British and American practice. He was struck, he said, by the difference between the aims in the two countries, the effort here being directed toward reducing cost as much as possible to make the product available to the greatest possible number, whereas in Europe the concern is more for the ultrarefined product for the smaller number of users. This divergence of aim may, however, be more apparent than real

and due to the different circumstances prevailing in the different countries. In America it has been necessary to develop a means of transportation on a large scale, with the result that American companies are producing motor-vehicles of great value for the price and possessing qualities of a very high order. Commercial competition has coerced the British makers into making a close study of the methods employed in this Country and has jolted them out of some of the well-worn ruts, for which, the speaker said, he supposed he should express for his confreres their indebtedness.

With an inborn love for the production of the best, the British engineers have produced the light, efficient and fast vehicle having the characteristics associated with the light car that is now being made in considerable numbers in England. In this they may claim to have contributed something to the general pool of knowledge and to have pioneered a new line of development in the light, high-speed, highly efficient engine. In America we seem to be busily engaged now upon the small six-cylinder engine of the refined type having increased compression and doubtless higher engine-speed.

England Leads in Motorcoaches

Statistically, the United States is far in advance of England in passenger-car production and registration, in the ratio of about 256 to 1; in trucks, by a



Chairmen of Committees and Chief Speaker at the Business and General Session

(Top) John Younger, Chairman of the Publication Committee; Norman G. Shidle, Who Presented a Paper on the Engineer as a Business Man; and John A. C. Warner, Chairman of the Meetings Committee; (Bottom) Fred E. Moskovics, Chairman of the Constitution Committee; H. M. Crane, Chairman of the Standards Committee; and Vircent G. Apple, Chairman of the Sections Committee

ratio of 10 to 1; but in motorcoaches and motor omnibuses it is interesting to know that Great Britain has in operation about 120,000 against about 80,000 or 90,000 in this Country, and in motorcycles and side-cars it has a registration of 600,000. London is unique among the cities of the world in the organization of motor-omnibus traffic, more than 4000 omnibuses being in operation. An interesting development is going on through the islands in the replacement of electric street-railway systems by the motorcoach, as town after town is finding that the motorcoach or motor omnibus is the natural successor of the electric tram except where the traffic density is very high.

In body engineering there can be no doubt, said Major Beaumont, that the all-metal construction of frames, panels and all except the furnishings, fittings and upholstery will prevail in the future and this will come, of course, in the work of the body engineer.

The Engineer's Inferiority Complex

Discussing the Engineer as a Business Man, Norman G. Shidle asserted his belief that if anything is the matter with the engineer as such it is caused by an inferiority complex that has various manifestations One of these is the aggrieved feeling that the management or the sales department will not do things the way the engineer thinks they should be done, and that therefore the engineer's "style is cramped." Regarding this phase of the complex, Harry Tipper, sales manager of the General Motors Export Corporation, was quoted as saying that the overcoming of such a condition is just a part of the engineer's problem, and the speaker said that he believes that if things keep coming up over a period of years that seem to hamper the engineer, it is no one's fault but the engineer's. He must have enough salesmanship to sell his ideas to the organization and thus perfect the conditions under which he works so that he can fulfill his greatest mission.

Another bit of good advice mentioned was that the men in an engineering organization would make it much easier for their superiors to broaden the scope of the subordinates' activities and make possible their further development if the men would realize that their opportunity for advancement and greatest service depends 75 per cent on their actual ability as technicians and 25 per cent on the impression they make as to their judgment and their reaction to management problems. The importance of the position occupied by the engineer varies almost directly with his ability and willingness to think and act in terms of the general business needs rather than in those of strictly technical activity. Engineering thinking must now be business thinking, and the engineer must regard himself as an integral part of the whole organization and of the business world, and he must expect to have to convince others of the soundness of his own ideas. When the engineer gets the business aspect into his thinking, according to Mr. Shidle, he will have a positive instead of a negative mode of thought and will be able to get away from the defensive attitude of mind.

Three reasons given for the inability of an engineer, in any given case, to get his ideas put into practice are: his lack of ability to sell his ideas; the need of slightly revising the ideas to meet conditions regarding which he did not have complete information when they were conceived; and the possibility that his ideas may be no good.

If he would get away from the defensive attitude, the engineer must keep thinking ahead of the other departments of the organization in business terms, because, if the engineering department does not advance good commercial ideas to keep the business progressing, the management and the sales department will feel the obligation to do so. If the engineer is able to evolve constructive ideas that will advance the business and be profitable, and if he succeeds in selling them, he can work more enthusiastically and can keep the rest of the organization so busy that it will not be thinking up new ideas for the engineering department.

One more bit of quoted advice with which Mr. Shidle concluded his address was that authority is never delegated; it is earned. Whatever position a man holds in an organization, there always is some person or entity to whom or which he is responsible; but authority is not a matter of organization charts, it is a matter of individual ability to think broadly in a business sense, and it has to be earned.

The rest of the session was taken up with extended prepared and extemporaneous discussion on Mr. Shidle's paper, which inaugurates what is hoped will be a schedule of papers and addresses at future meetings in which some of the broader aspects of the engineer's work will be discussed. J. A. C. Warner said that he thought that all would agree that Mr. Shidle's subject was of a type about which more should be heard. He expressed the belief that one of the main reasons for the engineer's failure to "put over" his ideas was his lack of knowledge of what is going on in other departments, which is noticeable in almost all automotive organizations.

A responsibility rests upon the engineer, declared Edward P. Warner, to understand the application and the possible market for the product upon which he is working as an ecoromic as well as technical problem. At the same time a very definite responsibility rests upon the business man to get the engineer's viewpoint to be able to find the merit in a conception despite the inability of the proponent to put it effectively and dramatically before him.

Walter T. Fishleigh mentioned that Mr. Shidle's paper opened up a question which had been recognized for many years as one of the most serious for engineers, that of the inferiority complex. He had not been able for a long time to see why the engineer should not be trained along the general broad lines that the lawyer or the doctor is, so that he would be able to talk in a convincing way and get the management and the public to agree with him.

Canada and England

Canadian Aerial Exploration Brilliantly Depicted and British Motor-Car Trend Reviewed

A SERIES of about 50 beautiful colored aerial photographs of Canadian scenery and a highly interesting account of the airplane exploration work and map making by the Canadian Government during the last 5 years were given at the Foreign Session in the ballroom on Wednesday night by A. M. Narraway, assistant director and chief aerial surveys engineer of the Topographical Survey of Canada. Maurice Platt, of London, was unable to attend the Summer Meeting of the Society, and Major Beaumont summarized Mr. Platt's paper on The Trend in European Passenger-Car Design and explained in an interesting way the lantern slides of the illustrations accompanying the paper. An address by R. S. McLaughlin, president of General Motors of Canada, was read in the absence of the author by H. A. Brown, vice-president and general manager of the same company.

The session, over which W. J. Davidson presided, was one that held interest for the ladies as well as the engineer members, and was one of the best attended of the meeting. A short and well-presented address was made by Maurice Holland, executive secretary of the American Committee on the World Engineering Congress, who gave much interesting information about the next Congress which is to be held in Tokyo a year from next October, and also about the engineering progress that the Land of the Rising Sun has made since the World War.

Considerable interesting information about the Dominion, from the historical and development aspects, particu-

THESE TOLD THE MEMBERS SOMETHING ABOUT CANADA'S DEVELOPMENT AND UNDEVELOPMENT

W. J. Davidson (Top), Chairman of the Foreign Session; A. M. Narraway (Left), Assistant Director of the Topographical Survey of Canada, Who Delighted a Large Audience with Entrancing Colored Aerial Photographs and Told of Airplane Exploration in the Dominion; and H. A. Brown (Right), Who Presented the Address by R. S. McLaughlin, President of General Motors of Canada, on the Resources, Highways, and Industries of the Provinces

larly as regards automobiles, highways and industries, was given in Mr. McLaughlin's paper. Canada is absorbing motor-cars at an ever-increasing rate, he said, and when it is considered that the automobile costs nearly 40 per cent more in Canada than in the United States, it is a remarkable evidence of national prosperity and progressiveness that, with a population of about 9,000,000, there are now registered more than 1,000,000 cars, and the annual consumption of new cars in the Dominion is about 160,000. The influence of the automobile as an all-year-round necessity is resulting each year in more determined efforts to keep the roads open in the winter, and last winter Ontario Province kept open about 700 miles of highways.

Despite her sparse population and great area of undeveloped north country, Canada is making progress in road construction. In the Province of Ontario, for instance, a road has been built, the author stated, three-fourths of the way from the Niagara frontier to James Bay, which is part of Hudson Bay. It is known as the Ferguson Highway and has the distinction, aside from its engineering interest and the remarkable country through which it passes, of having stretches of 50 to 60 miles without either filling stations or hot-dog stands. It traverses magnificent farming country and great timber lands, and on or near it are some of the world's greatest mineral areas, including the second largest gold-producing mine in the world, and nickel deposits estimated to contain 95 per cent of the world's supply. Very recently a highway was opened from the Ferguson Highway into the new rich mineral areas of Quebec Province, which is one of the largest producers of precious metals on the American Continent.

The Hudson Bay Railway through Manitoba Province should be completed next year to Fort Churchill, on the tidewater shore of the bay. Alberta Province has rediscovered the Peace River district, 400 miles north of Edmonton, where the summer days are as long as 22 hr. and which is capable of producing as much wheat and other grain as the entire Dominion is now raising. The northern march of the automobile is indicated by the fact that Mr. McLaughlin's company now has dealers in Dawson City and other Yukon points not many miles south of the Arctic Circle. Although the great stretch of undeveloped country between the Great Lakes and the prairie provinces to the west and the far-western mountain ranges have so far been big obstacles to highway building there, it is hoped before long to link up the roads of eastern and western Canada. Only a few minor gaps remain in the transcontinental route, and the last link in the chain of roads through the Rocky Mountains is now being forged.

EXPLORATION BY AIRPLANE

Upper Canada is fast emerging from the unmapped and undeveloped wilderness state through the instrumentality of the airplane. In his paper on The Airplane in Canadian Exploration, Mr. Narraway told how the enormous natural resources are being brought to light and made more accessible in the undeveloped four-fifths of the Dominion by means of the airplane. Canada's contribution to aviation has not been fully appreciated, according to the speaker, because, fortunately, the money has not been available for polar or transatlantic flights, yet Canada has attained a leadership in at least one branch of aeronautics—that of aerial surveys and investigations. Within the last 5 years she has photographed from the air more than 200,000 sq. miles of hitherto inaccessible country that is richly endowed with natural resources such as timber and ores. This accomplishment is equivalent to eight flights entirely around the world, with a photograph of every foot of the way. Against the polar and transoceanic flights, Canada sets the aerial protec-

tion from fire of 200,000,000 acres of forest land each year, the type mapping of 30,000 sq. miles of almost completely unmapped country per season, and the revolutionizing of the geological survey which provides the mining engineer with the initial step in the examination of the mineral resources of the country.

These achievements have moved at least one generation ahead the development of the Dominion's resources, and thus the airplane is playing a most important part in advancing the prosperity of Canada and her place among the nations of the world. Canadians are now looking to the automotive engineers, said Mr. Narraway, to provide airplanes that will be fully capable of giving the necessary performance to enable the fliers to perform their exacting duties with efficiency and all reasonable safety. Canada looks to the Royal Canadian Air Force to provide and equip suitable airplanes and to send them into the air every day that is suitable for photography with a pilot who shall maintain a definite altitude, even keel and constant speed. Experts of the Topographical Survey then take bird's-eye photographs of the country. Thus the airplane increases the rate of investigation by the geologist, the forester, or other expert from 1 or 2 to 70 or 100 m.p.h.

Maps with Vital Information

Mr. Narraway explained the details of aerial map-making and how type maps are made from the photographs, designating different types of country by means of different colors so that the forester or the geologist has all the essential information to enable him to start development work. Perhaps the greatest advance in aerial surveys in the last year, he said, is the application of photography to investigation of water-power resources, the maps giving the water-power engineer certain knowledge of the headwaters of the streams and the drainage areas. Examination of the photographs with a stereoscope reveals the hills and valleys with exactness, notwithstanding the concealing bush. They afford invaluable information, also, to those engineers who are engaged in the construction of railroads, transmission lines and highways.

Approximately 172,000 photographs have been taken in the last 5 years, of which 50,000 were added last year. The Aerial Surveys has worked out a national map of Canada based upon latitude and longitude and giving uniformity and coordination throughout the length and breadth of the country.

Following the delivery of his paper, Mr. Narraway showed about 50 lantern slides of views taken from the airplanes and explained how the topographic surveys are made.

Mr. Holland, who is director of the division of engineering of the National Research Council in the United States, stated in his address on the coming World Engineering Congress in Tokyo, that it is the proposal of this Congress to American engineers to build, with the engineers of Japan, the first span in a bridge of brotherhood of engineers around the world. The significance of the Congress to the automotive industry and engineers is reflected in the fact that imports of motor-trucks and motorcoaches into Japan increased 300 per cent in 1927 over the preceding year. The 18,000 jinrikshas in use in Tokyo 10 years ago have now decreased to 2000, with nearly an equal number of taxicabs. Approximately 10,000 motor-cars are imported annually, and 40,000 automobiles and trucks are now in use in Japan.

On the American committee of the Congress the automotive industry is adequately represented by C. F. Kettering, Howard Coffin, J. H. Hunt and C. B. Veal. Secretary Herbert Hoover is the honorary chairman of the committee, and Elmer A. Sperry is the chairman.

European Engineering Trends

European trends in some of the major features of engine, chassis and body design and in several items of car equipment were reviewed in the paper by Maurice Platt, which was summarized by Major Beaumont. The subject was divided by the author into four parts, in which he discussed popular chassis types, trends in chassis design, development in body-work and equipment, and chassis changes in prospect. Some of the more notable developments and trends are the small, high-speed, high-efficiency engines used in light cars; increase in six-cylinder engines, unit engine and transmission construction, single-plate clutches, and four-wheel brakes; flexible and three-point suspension bodies and convertible bodies; elimination of running-boards and the carrying of the body panels and doors down below the side frames; independently sprung wheels; front-wheel drive; and supercharging.

Mr. Platt's paper is expected to be printed in full in an early issue of THE JOURNAL.

Beauty Has Sales Appeal

Modern Art and Its Application to Automobile Design Ably Discussed by Paul Thomas

ALL the elements of an instructive and enjoyable session were assembled in the ballroom of Chateau Frontenac on the evening of Thursday, June 28. With a capable and entertaining chairman like H. Ledyard Towle of General Motors Corporation; an authoritative and interesting speaker like Paul Thomas of Cheney Bros. Co.; brilliant discussers such as F. E. Moskovice of Stutz Motor Car Co. of America, Inc., H. M. Crane of General Motors Corporation, and F. A. Cornell of C. G. Spring & Bumper Co.; and a representative audience of automotive engineers and their wives to function as creative listeners, the success of the Body-Design Session was not only assured but inevitable.

PAUL THOMAS
He Told of Body Lines and Appeal to Women at the Body-Design Session

Before introducing the speaker, Chairman Towle spoke of this period in which we are now living as the age of the American renaissance. He pointed out that we have gone through the time of learning to make things function and have come to the time when we are beginning to learn to beautify them. He added, moreover, that we are learning that beauty is not only esthetically wonderful but is capable of returning actual cash to us in its sales appeal to the public.

Characterizing copying as the curse of American industry today and stating that it is possible to achieve individuality and at the same time to completely avoid freakishness, Paul Thomas mentioned two ways of setting about the creation of new designs. The first way is to try to think of something that has never been done before; the second, and perhaps the better, way is to search deeply for the

inherent qualities of the product to be designed and the purpose for which it is to be used and make the design expressive of these qualities and this purpose. The automobile, said Mr. Thomas, inherently represents several things, some of them being power, speed and graceful flight.

The streamline principle was mentioned in this connection as being a sound design because it is a principle derived from the object itself, not something applied from the outside or borrowed from some other field of decoration. The discovery of the streamline principle of design, said Mr. Thomas, was the most important single factor in breaking the automobile away from the horse-and-carriage age; with the first streamlined car, the term "horseless carriage" became obsolete.

Follow Fashions, Not Fads

The automotive engineer, Mr. Thomas said, should realize that fashion is a fundamental part of life, originating in our mode of living, our ways of thinking, and our attitude toward life. He defined fashion as something that appeals to the public with qualities beyond its practical or utilitarian appeal, and urged his hearers not to confuse fashions with fads. Simplicity, he said, should be the keynote.

As color plays such an important part in modern art, the use of color in automobile design needs to be considered carefully. Mr. Thomas emphasized the idea that color schemes should be worked out not only with the idea of making them different from any others that have preceded them but with the thought of making them accurately express the public mood in color and be linked up with the color trends in vogue.

One of the most significant statements in Mr. Thomas' paper was to the effect that by following the fundamental principle of making design express the inherent qualities and characteristics of the car and making it express the public's attitude toward automobiles, the engineer can go on designing cars endlessly, practically without repetition, because of the wealth of characteristics to express and the constantly evolving and changing attitude of the people to give additional keynotes.

Variety at Chassis Session

Brake Legislation, European Roads, and Increasing Engine Power Discussed

EACH of the three papers presented at the Chassis Session, Wednesday forenoon, June 27, in the ballroom of the Chateau, brought much interested discussion. Prof. E. H. Lockwood, of the Sheffield Scientific School at Yale University, delivered a paper by himself and H. W. Best on Legislation on Automobile Brakes; Tore Franzen, of the Detroit Steel Products Co., in his paper on European Roads and American Cars, presented an aspect of car design that was new to some of the engineers present; and Thomas J. Litle, Jr., chief engineer of the Marmon Motor Car Co., told of methods whereby a greater power-output can be obtained from a given engine. Past-President B. B. Bachman presided as chairman.

The Lockwood and Best paper deals with existing motor-vehicle laws as they relate to the requirement for two independent systems of braking mechanism, which are now regarded by some as obsolete because of the safety of the four-wheel braking mechanism. The authors quote the proposed uniform brake law formulated by the Eastern Conference of Motor-Vehicle Administrators and raise the question of the interpretation that may be put upon a clause of the proposed law which requires that every automobile shall be equipped with at least two braking systems with at least two separate means of application, each operating on at least two wheels.

Written discussion on the subject was submitted by George L. Smith, of the United States Ordnance Co.; Benjamin Eynon, Registrar of Motor Vehicles for Pennsylvania; Charles A. Harnett, Commissioner of Motor Vehicles of New York State; John F. Griffin, Commissioner of Motor Vehicles of New Hampshire; and James M. Hayes, Director of Motor Vehicles of Virginia. Chairman Bachman stated that he had a communication also from the office of Mr. Atwood, of the State of Rhode Island.

But The Public Really Pioneered

FIRST HAND PARKING BRAKE

Brake-Torque Equalization Proposed

Briefing his discussion in a short talk, Mr. Smith showed by means of a chart projected on a screen the probability that the driving speed will go to 90 m.p.h. by 1940, and pointed out two factors controlling the maximum brake power obtainable are the coefficient of friction of tires on the road and the shift of weight from the rear to the front wheels as the car decelerates. The danger from brakes, he said, is the result of three causes: (*a*) unbalanced brakes, causing the car to steer off the road; (*b*) badly unbalanced brakes, causing side skidding; and (*c*) one or more locked wheels, producing or magnifying the foregoing dangers. He advocated the combination of braking-torque equalization with a variable-ratio control of front and rear brakes, saying that torque equalization gives a correct balance of brake force so that there is no need of easing off the outer front brake when making a turn and makes possible the use of a tell-tale for warning the operator if the brakes are out of adjustment before the condition becomes dangerous. A pedal operating front-wheel brakes in combination with a transmission brake of conventional design and an emergency lever that operates to contract the transmission brake give two independent operating systems at no extra cost.

Divided Opinion on the Subject

In the course of the general discussion following Mr. Smith's prepared discussion, considerable difference of opinion developed among the engineers present as to the advisability of the requirement of two independent braking systems as now required by State laws. Illustrating his remarks with drawings on the blackboard, J. A. C. Warner indicated what may be expected from a particular type of brake hook-up mentioned inferentially in Professor Lockwood's paper. He asserted that the brakes on three of the wheels can be disconnected successively without destroying the braking effect on the fourth wheel, and that even the cross-shaft of the brake hook-up can be cut in any one place and still the foot brakes can be applied on two of the wheels and the hand brake on the other two wheels. With such a system available, it would be as logical, in order to provide adequate safety, to insist that we have two separate

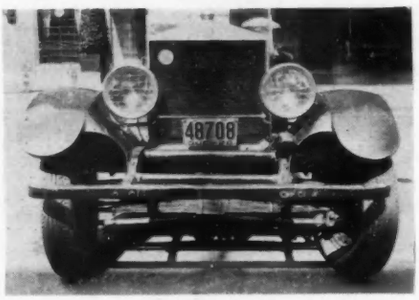
steering mechanisms as to require two separate braking systems, concluded Mr. Warner.

A different attitude was taken by W. R. Strickland, however, who spoke of the difficulty of obtaining cooperation between the manufacturers and the different legislatures and of the fact that brakes do fail occasionally, one of the worst causes being the wearing of brake-bands. Although they have been improved, the linings still wear out, and with the four-wheel brakes the braking leverage has been increased to secure easy operation, so that the pedal is likely to go down to the floor-board and leave the car without sufficient braking. It is the duty of engineers to work for safety first rather than simplicity and low cost and to sell this idea to the management of their companies. He thinks that less opposition by engineers and more cooperation with the authorities who insist upon double braking systems will get us farther ahead.

Along the same line, M. C. Horine, of the International Motor Co., spoke of the greater necessity of adequate braking on heavy vehicles such as trucks and motorcoaches, and of the heating of the drums as a factor in the problem. He advocated two independent systems of brakes throughout so that the sets of drums on a vehicle can be used alternatively in descending long hills, thereby giving opportunity for better dissipation of the heat. The application of a secondary braking system to the same drums is not a solution, because the lining becomes burned by contact with drums that are already heated; for this reason he believes that the motor-vehicle administrators are right in holding out for an independent system, which should extend even to the drums.

Spring Suspension for European Roads

Car-suspension problems as presented by road conditions in Continental Europe were dealt with by Mr. Franzen in his paper, with particular reference to complaints of weak springs and striking of the car frame on the axles. The speaker classified the European roads into two general types and the Continental motorists also into two types. Pointing out that the old stone highways are now rough and poorly maintained, he said that the motorists who drive for sport complain of "striking through," and said that the obvious solution of this is the use of stiffer springs. The larger class of owners, who want to ride in comfort and whose cars are driven by chauffeurs, frequently use very low tire-pressure and consequently shimmying often results. The dirt roads of Europe are mostly badly rutted and very rough but must be traveled by



Car With Independently Sprung Wheels Driven to the Meeting by J. A. Wright

the European motorists. To obtain easy riding, over-oiling of the springs and of the shock-absorbers is rather general, and with the conventional drum type of shock-absorber "striking through" results and complaint is made that the springs are weak.

Although no drastic change in the present spring-suspension of American cars to adapt them to these conditions is to be considered, said the author, some important things have been learned that would be of considerable assistance in designing suspension for export cars. It should, he thought, be a relatively simple matter to develop a special suspension for certain countries, which suspension would deviate but little from the present, so far as springs are concerned, but particular attention should be paid to the shock-absorbers. These should be fool-proof, quiet and effective.

Wagon Springs Out of Place

A long discussion on spring suspension followed the conclusion of Mr. Franzen's paper. W. R. Strickland pointed out that even with our network of good roads we shall always have some bad conditions arising from the wearing out of the roads, and that we have the problem of making a compromise between the soft, easy ride on smooth roads and the hard ride over the bumps. No matter how good the suspension and control of a car are made, the limit in this direction will be reached, because the American driver always will drive as fast as the road condition will let him. W. E. England, of the F. B. Stearns Co., said he does think American drivers drive as fast as they can any more, but that 45 m.p.h. is about the top speed. President Wall raised the question whether our cars ride better today than in the past or merely seem to do so because the roads are better. One problem is to decide how heavy the springs should be, as it is very difficult to design a car with springs sufficiently light to give easy riding yet that will not let the frame strike when passing over an extreme bump. It seems impossible to make springs that will meet all conditions without the assistance of shock-absorbers.

Individually sprung wheels were suggested by Herbert Chase as a possible solution of the problem, and he said he thought we should try to visualize a complete revision of the spring suspension of our cars, virtually all of which have the same type of spring although it is by no means certain that the present system is the best.

Independent Wheel-Suspension a Solution

Reverting to independent wheel-suspension, James A. Wright told of conducting experiments in this field since 1921 and having 79 patents granted or pending on designs applicable to automobiles, trucks, motorcoaches, tractors and railroad rolling-stock. He said he had ridden to Quebec from Montreal in a car having independently sprung front and rear wheels and had been much interested in the comments of others who have traveled the road in conventionally sprung cars regarding the driving conditions. With independently sprung wheels the unsprung weight is reduced approximately 60 per cent, he said; the road resistance is lowered considerably; the chassis is hung on the flexible ends of the spring, with the thick portion of the spring in the middle of the chassis; and a very nice application of steering is realized.

The stresses and action, said Mr. Wright, are entirely different with independently sprung wheels, which he is convinced are the solution of the problem of car suspension and also of the braking question.

Agreeing with the strictures of previous speakers upon the wagon type of suspension as being fundamentally

LUMINARIES WHO THREW LIGHT ON THE CHASSIS QUESTION

B. B. Bachman (Top), Chairman of the Chassis Session; Tore Franzen (Upper Left), Whose Paper on European Roads Started a Car-Suspension Discussion; T. J. Litle, Jr. (Upper Right), Who Told of Ways of Life Extension for an Existing Engine-Design; Prof. E. H. Lockwood (Left Center), of Yale University, Who Delivered the Paper by H. W. Best and Himself on Brake Legislation; George L. Smith (Right Center), Who Presented Written Discussion on Brake Legislation; Lee W. Oldfield (Lower Left); W. E. England (Lower Center), and James A. Wright (Lower Right), Who Discussed Independent Suspension

wrong. Lee Oldfield stated that, in the individual wheel-suspension used in the light delivery vehicles being built by the company with which he is connected no sign of difficulty has been encountered, although it is the cheapest type to build and more than 200,000 miles have been covered experimentally by these vehicles.

Use of Helical Springs Recalled

Suggestion was made by Joseph Anglada that, instead of following what everyone else is doing, it may be well to try to evolve a different and cheaper form of suspension, or, if continuing to use leaf springs, to put more money into them and use a larger number of thin leaves, which undoubtedly improves the riding-qualities. He recalled, in this connection, the triple sets of helical springs used by Lansden in his light electric vehicles about 20 years ago, on which Mr. Anglada conducted several tests to determine the current consumption and the necessary battery capacity. As compared with electric vehicles of similar load capacity and having leaf-spring suspension, he had found that the current consumption was considerably less and also that the riding-qualities seemed to be superior. He also recalled Walter Christie's front-drive racing car, which had helical springs and attained a speed of 80 to 90 m.p.h. and rode very well when fitted with proper shock-absorbers.

Speaking on the theme that it is more economical to redesign and improve an existing engine model to get a greater power output than to design an entirely new one, T. J. Litle, Jr., listed the methods of accomplishing the desired result as: increasing the engine speed, increasing the volumetric efficiency, increasing the compression ratio, increasing the thermal efficiency, and increasing the mechanical efficiency. He dealt in order with the possible means of accomplishing each of these results. Although better materials and greater care in manufacture must be used and much more attention given to balancing all the moving parts in a high-speed engine, he is firmly convinced that engine speeds will be further increased, and the cost will be offset in part by a great saving in metal. If manufacturers would pay more attention to balancing there would be much less opposition to the high-speed engine, he said, and hinted broadly at the probability that an entirely new type of balancing device to be announced within a few months, designed to reduce almost all the torsional vibration periods as well as the angular vibration, will soon make the heavy flywheel type of vibration damper obsolete.

In conclusion, the speaker stated that it is a distinct advantage to keep the engine weight as low as possible and that, instead of basing engine performance on piston displacement, a more significant comparison would be the engine weight per horsepower. If superchargers should be made as accessories to be adapted to existing engines, a given engine could be perpetuated over a period of several years to meet the demand for more power, as this is the most effective means known for increasing engine performance.

Carburetion as a Factor

Sometimes an engine does not respond with full power promptly when the accelerator is depressed to open the throttle, said Herbert Chase, and an engine that is capable of giving high maximum power is condemned simply because it is not capable of giving that power quickly. In this connection, carburetion probably should be given more study than it is receiving. It seems certain that some engines have a speed period at which the carburetion is unsatisfactory or some manifold condition makes it impossible to get the engine above the critical speed although it is capable of developing more power at higher speed.

A great deal of work is being done on carburetion, heating of the mixture and the like to correct the condition, said Mr. Strickland. In the development of maximum power on hills, a great deal depends on whether the climb is started just as it is reached in a run or is begun after a wait. Considerable difference in this regard has been noted at the General Motors Proving Ground.

The two-stroke-cycle engine seems to offer the greatest possibilities of getting greater horsepower per unit of weight, said Mr. Oldfield, who referred to an experimental engine of this type at Valparaiso, Ind., that idled at 85 r.p.m. without missing an explosion.

Mr. Litle agreed that the development mentioned is very important and that the two-cycle engine is probably coming, but said that in his paper he was dealing only with existing engines, which are not easy to change from four-stroke to two-stroke.

Two Novel Design Features

Continuously-Variable Transmissions and Front-Wheel Drives Discussed

TWO design features which, while not new to automotive engineering thought, are novel in that they have not been adopted into current automotive practice, were the topics brought before the Transmission Session on Thursday afternoon. These are front-wheel drives and a device for securing continuous progressive gear-changes.

Herbert Chase, in his paper entitled Front-Wheel Drives, Are They Coming or Going? placed the date for the first front-wheel drive to be put into actual use as 1862, and the period of its early application to gasoline-driven vehicles from 1900 to 1905. D. Sensaud de Lavaud, in introducing the description of his transmission in his prepared paper, set the initiation of thought on continuously progressive changes in speed coincident with the inauguration of automobile locomotion. However, while the front-wheel drive has forged into the foreground of attention through both its application to racing cars and the interest attributed to some manufacturers in its possibilities for incorporation in passenger-car design, the automatic transmission has not gained so strong a foothold, at least on this side of the ocean.

Encyclopaedic in nature, Mr. Chase's paper reviewed the advantages and disadvantages of front-wheel drives, classified existing designs into three classes, and presented numerous illustrations of specific constructions. The material for the paper was collected by an investigation throughout the industry, conducted by means of a questionnaire addressed to chief engineers, and by a thorough search through the technical literature of the last decade or more. The thoroughness and inclusiveness of the paper, which, as W. T. Fishleigh, chairman of the session, pointed out, were to be expected from Mr. Chase's long and close association with the automotive industry, make it of particular value.

An interesting by-product of the questionnaire, as pointed out by Mr. Chase, in the discussion, was the collection of opinions from chief engineers as to what major improvements they considered more important than the front-wheel drive. Some of the design features signalized as of greater promise are: individual wheel suspension; very high-speed engines with cuff valves; radical changes in fuel-handling systems to improve thermal efficiency; two-speed axles or over-speed transmissions; rear-located powerplants, particularly for motorcoaches; automatic brake-adjustment; and development involving omission of the present transmission, in other words, a substitute for the present gearset.

CHAIRMAN AND SPEAKERS AT THE TRANSMISSION SESSION

Walter T. Fishleigh (Top), Who Wielded the Gavel; Joseph A. Anglada (Left), Who Took Part in the Discussion; and Herbert Chase (Right), Who Reviewed Front-Wheel-Drive Developments and Wanted To Know If They Are Coming or Going

M. C. Horine elaborated on one of the points made, the tendency in designing modern high-capacity motor-coaches to place the engine behind the rear axle so as to obtain more seating room without increasing the wheelbase. If we find now that we should drive the front wheels, why not, he asked, just turn the bodies around; then the driving axle and brakes will be in front, and the engines in the rear.

CONCLUSIONS DRAWN FROM RACING

What conclusions should be drawn from the experience with front-wheel drives in this year's 500-mile classic at Indianapolis was a topic also discussed. President William G. Wall expressed the opinion that the relatively poor showing of the front-wheel-driven cars should not be construed as an argument against this type of drive, since the troubles experienced by these cars were caused for the most part by superchargers, leaky gasoline tanks, and other parts not connected with the power-transmission system. Lee Oldfield, while conceding that the breakdowns during the races were not due directly to front-wheel-drive mechanism, pointed out that most of the failures of supercharger driving-gears were experienced on cars with front-wheel drive. He explained this on the ground that cars so driven do not get tractive effort in acceleration. The spinning of the wheels subjects the supercharger drive-train to heavy loads and so leads to failures. He did not feel, he said, that tractive effort is obtainable with the front-wheel drive.

As is usual in technical sessions, much valuable information regarding experimental work done was introduced informally into the discussion. President Wall told of trials made during the war with four-wheel-driven trucks, disconnecting first the front and then the rear-axle drives. The majority of observers were of the opinion, he said, that better results were obtained with the front than with the rear drive, and almost as good results with the former as with the four-wheel connection. Joseph A. Anglada took issue with the argument that less power is required to drive a car by the front wheels than by the rear wheels, and cited tests made with electric cars to disprove this assertion.

In concluding the discussion, Mr. Chase reinforced a plea previously made by Chairman Fishleigh for constructive thinking with regard to front-wheel-drive possibilities, thus emphasizing the necessity for forward-looking thought stressed in a number of sessions throughout the meeting.

RADICAL ACTION TO SIMPLIFY CONTROL

D. Sensaud de Lavaud's paper incorporating the description of the transmission designed by him, its application to cars of various weights, and an analysis of the action of its elements was read by title. The meeting was then thrown open for discussion, most of those present being familiar with the contents of the paper through its previous distribution in preprint form.

"Take the jumping jack out of the front seat" was the slogan for a large part of the discussion, referring to the desirability of simplifying the control of present automobiles. Chairman Fishleigh again sounded the note of active, unconventional engineering thought when he said, in this connection, "This is not going to be one of the features in which we progress slowly from step to step and finally develop a perfected design. I think it is generally agreed that it calls for radical action, perhaps a complete change in control and transmission."

Dr. H. C. Dickinson also looked into the future in referring to two facts in power production and transmission which, while not seriously considered now, may, after the passage of a few years, press forward for attention. The first is the fact that about 60 per cent of the fuel burned under average driving conditions is used to overcome friction in the engine; the other is that present engines turn over from two to four times as many revolutions as they need to do for the number of miles covered.

Four Subjects at Engine Session

Engine Indicator, Valve-Spring Design, Engine Fuel Supply, and Crankshaft Distortion

AT Thursday forenoon's session Dr. E. J. Martin gave a paper prepared by himself and D. F. Caris, both of the General Motors Corporation Research Laboratories, in which the development of engine indicators was reviewed and a number of instruments were described, concluding with an exposition of a new electrical indicator developed in the General Motors laboratories. This paper is printed in full in the papers section of this issue of THE JOURNAL.

A paper on Crankshaft Distortion Research, written by C. A. Norman and K. W. Stinson, of Ohio State University, and presented at the session by title only, also appears in this issue.

W. R. Griswold, of the Packard Motor Car Co., read an analytical paper dealing with research on valve-spring breakage and the development of the new Packard dual poppet-valve spring. This was prepared by him in collaboration with Alfred Moorhouse.

Various existing and probable future methods of supplying fuel to an engine were dealt with by F. G. Whittington, of the Stewart-Warner Speedometer Corporation, based on laboratory results and road tests conducted by this company.

As presentation of the papers occupied all of the forenoon, no time remained for discussion of the subjects.

Some time ago an attempt was begun in the Packard laboratories to make a complete rational analysis of the entire valve-spring problem as presented in modern engines operating in some cases at maximum speeds around 3600 r.p.m., with the purpose of determining all of the principal factors involved in valve-spring operation for long expectancy of life. This analysis seemed to divide logically into determinations of what can be the normal stress-ranges for any given spring material having reasonable uniformity for a life of say 100,000,000 cycles of stress, and what are the effects of the dynamics of the valve gear in producing secondary stress. The latter part of the investigation included the spring forces involved and surging of the center coils. A final summary of all the analyses considered by the authors includes the following main points upon which to design a suitable valve spring:

(1) The value of the rate of action of the spring in pounds per inch divided by the weight of the spring in pounds must be high
(2) Valve-spring breakage is attributed to too high a stress superimposed on the static stress
(3) The static-stress range and the maximum stress must be within safe limits
(4) Unharmonic waves in the spring may excite harmonic vibrations in the spring
(5) Shape of the valve-lift curve has some influence on vibrations in the spring
(6) Load requirements and high valve-lifts make the design more difficult by a two-fold effect: (*a*) high valve-velocity and (*b*) high stress-range.

THE NEW DUAL VALVE-SPRING

Based on the foregoing points, a dual valve-spring was designed that is simple and practical, the end pieces being made from bar stock and completely machined in automatic screw-machines, with the exception of the key slot, and both ends are grooved with two series of grooves. Deep grooves receive the spring, while shallow grooves are provided to allow a swaging operation. The lower end-piece functions also as the spring seat at the keyed end of the valve. In assembling, one spring is screwed into the bottom piece until the squared end butts against a key in a small holder. The other spring is then hooked into one coil of the first spring and screwed down to the fixture so that the two springs intercoil. The upper piece is placed on the free end of the springs and screwed into place. Next the threads are swaged down around the wire in the grooves in a machine that rolls the metal down while the spring is rolling between two dies, the distance between which progressively diminishes to the required outside diameter of the spring. The springs are then tested for torsion on an air-operated fixture.

Several wire stocks were tried and tested before finally adopting a plain carbon-steel stock that showed excep-

THE THREE SPEAKERS AT THE ENGINE SESSION

(Left to Right), W. R. Griswold, Who Presented the Paper by Alfred Moorhouse and Himself on the Packard Dual Valve-Spring; Dr. E. J. Martin, Who Delivered the Paper on a New Electrical Engine Indicator as Coauthor with D. F. Caris; and F. G. Whittington, Who Described 10 Present and Prospective Ways of Supplying the Fuel Mixture to Automotive Engines

tional results in the twisting test. Except for a single failure, all sets of springs made of this material and so far tested have run 300 hr., and results in service have been very gratifying, according to the authors. Although these dual valve-springs have been in production for more than a year, not a single spring has broken in service. Other advantages displayed by this type of spring construction, as listed by the authors, are

(1) Increased smoothness and quietness of the valve gear at all speeds, especially at idling speed
(2) Elimination of rotation of the valves and consequent reduction of valve-seat wear
(3) Reduction of valve-stem-guide wear to a negligible point because of the balanced load on the valve-stem
(4) General preservation of the valve-operating gear by the elimination of valve clatter and jumping of the roller on the cam.

Ten Ways of Supplying Fuel

Summarizing the results of research and actual performance, Mr. Whittington listed at the conclusion of his paper 10 ways of supplying fuel to the engine, as discussed in the paper. The first four involve the use of a standard carbureter and a vacuum tank operating (*a*) on available vacuum at the inlet manifold, (*b*) with a booster to assure fuel supply at low inlet-manifold vacuum, (*c*) with a trap valve assuring sufficient vacuum to supply fuel under all working conditions, and (*d*) with a vacuum pump coordinating with the manifold vacuum and giving high vacuum at all times. The next two methods involve the use of a standard carbureter together with (*a*) a mechanically driven fuel-pump of the diaphragm type pumping directly from the main supply tank and delivering to the carbureter, and (*b*) an electromagnetic fuel-pump of the plunger type mounted on the main supply tank.

The seventh method calls for a combined carbureter and circuit-control unit operating an electromagnetic pump on the supply tank; and the eighth for a combined unit incorporating a carbureter, a circuit-control unit and an electromagnetic pump.

The ninth is a direct fuel system having no conventional form of carbureter, no vacuum tank and no fuel-pump, but taking the fuel directly from the main tank by special jetting means, vaporizing it and adding cool air to approximate as nearly as possible a dry mixture for the engine.

In the tenth method a diaphragm carbureter is used in conjunction with a vacuum tank or a fuel-pump of any type, the carbureter design incorporating improvements to assure a marked increase of engine power-output in most cases.

The direct fuel-supply system has numerous advantages, the principal one of which is that it supplies the gas for engine operation in a highly vaporized state and allows the use of large manifolds which are favorable to volumetric efficiency. The complete installation embodies a small vertical pipe carrying air to the lowest part of the fuel tank where it connects with a properly proportioned jetting means and produces a mixture that is conducted to a heating element mounted directly in the exhaust manifold. Here the heavier parts of the mixture are acted upon by very high temperature while the lighter ends pass through. At the point of vaporization the heavier ends are passed on to the air-mixing chamber, where the gases come under throttle control. Heating of the preliminary mixture by the exhaust results in fast warming-up and easy engine-starting, while cooling of the vaporized mixture by subsequent admission of cool air in the ratio of about 4 to 1 results in high volumetric efficiency. Thorough vaporization assures smoothness of operation, increased horsepower and better fuel economy. According to Mr. Whittington, this radical direct fuel-system shows a performance that is worthy of attention, and it should be considered seriously as a reliable means of furnishing an adequate supply of fuel to the engine.

Volatility and Acceleration

Fuel Characteristics and Engine Performance Topics at Research Session

THE two papers presented at the Research Session on Friday morning represent two distinct advances made by the Cooperative Fuel Research into the field of knowledge of fuel characteristics and their relation to engine performance. They are further evidences of the value of that joint project initiated by the automotive and petroleum industries 6 years ago and fostered ever since by both industries, through the National Automobile Chamber of Commerce, the American Petroleum Institute, and this Society, the experimental work being carried out at the Bureau of Standards. The two subjects treated were volatility, dealt with by Oscar C. Bridgeman in his paper entitled Dew-Point Data on Gasoline, and engine acceleration, the subject of Donald B. Brooks' paper, The Influence of Fuel Characteristics on Engine Acceleration.

Dr. O. C. Bridgeman

Bureau of Standards Research Expert, Who Presented a Paper at the Research Session on Dew-Point Data on Gasoline

Dr. Bridgeman's paper fills one of the gaps in the investigation carried out for the purpose of providing some yardstick whereby the distillation curves of the American Society for Testing Materials may be interpreted in terms of greater significance to the automotive engineer. Previous work has covered the development of an apparatus and a method for obtaining equilibrium air-distillation curves for gasoline; a correlation between volatility data obtained by this method and the distillation curves of fuels as determined by the procedure practised by the American Society for Testing Materials for the volatility range between the 10 and the 90-per cent points; and the relation between these volatility data and the ease of engine starting.

In his paper Dr. Bridgeman dealt with the temperature of 100-per cent equilibrium vaporization in the presence of air, a point of considerable interest in normal engine-operation. He described dew-point measurements made by the Bureau of Standards by three independent methods, which show good agreement with one another and with values obtained by other investigators. From the results obtained, the normal dew-point seems to be computable with accuracy from the 90-per cent A.S.T.M. point by means of the ratio 1.084, if both temperatures are expressed in absolute degrees. The 90-

DONALD B. BROOKS

Whose Paper on The Influence of Fuel Characteristics on Engine Acceleration Was a Further Contribution from the Bureau of Standards to the Series on the Cooperative Fuel Research

per cent point was also shown to be a real criterion of the volatility which is of interest under normal operating conditions in an engine. A classification of gasolines on the basis of this point, Dr. Bridgeman indicated, would give information suitable for the selection of fuels best adapted to particular designs of engine manifolds. On the other hand, the end point frequently used for this purpose was shown to be misleading.

Further investigation on the subject of gasoline volatility will cover the lower part of the curve, between the 0 and 10-per cent points.

CONCLUSIONS FROM ENGINE ACCELERATION TESTS

One of the first problems encountered in the study of engine acceleration, the subject of the report rendered by Mr. Brooks, was that of instrumentation. Apparatus and procedure designed to give results of greater accuracy than hitherto have been obtainable and to eliminate experimental error were developed and two sets of tests were run.

The first set had for its purpose the determination of the effect of certain factors on engine acceleration, and in this section of the investigation three fuels were used: aviation gasoline, commercial gasoline, and a blend composed of equal parts of the two. The factors studied were air-fuel ratio and manifold temperature.

To determine the effect of the A.S.T.M. 50-per cent point on engine acceleration was the object of the second set of tests, and this investigation was concentrated on three fuels which were substantially alike at the 20 and 90-per cent points and had 50-per cent points at 248, 284 and 326 deg. fahr. respectively.

The conclusions drawn from the experiments made are: (*a*) under conditions giving less than 50-per cent vaporization in the manifold, there is little effect of differences in the A.S.T.M. 50-per cent point with fuels having like 20-per cent points; and (*b*) under conditions giving slightly more than 50-per cent vaporization in the manifold, the primary influence of 50-per cent point is shown chiefly in the initial lag, although some variations in the acceleration are indicated by the tests.

F. C. Mock, in written discussion presented at the close of the session, mentioned the great educational value of the fuel-research program. He further stated that satisfactory acceleration, with an economical steady-running mixture and using fuels of present volatility, may be obtained in three ways: (*a*) by raising the air velocity through the carbureter and intake manifold so that it never falls below a certain minimum which will be between 30 and 70 ft. per sec.; (*b*) maintaining the air entering the carbureter at all times at 160 deg. fahr.; and (*c*) furnishing a temporary enrichment of the mixture or accelerating charge.

Quietness of Gears Featured

Ground Gears and Gear Correction Discussed at Transmission-Production Session

TWO papers, as well as both written and oral discussion, were presented at the Transmission-Production Session held Wednesday afternoon, June 27. The paper on Ground Gears and Transmission Design was excellently presented by H. F. L. Orcutt, one of the Society's guests from England, to a well-attended session. The paper advocated ground teeth for transmission gears because they can thus be made to the same degree of accuracy as the other fine working-parts of automobiles. Various arrangements of the gear assemblies, relative gear-shaft position and gearbox design, and the degree of accuracy used in manufacturing were discussed from the standpoint of quiet gear-performance.

In the general discussion of Mr. Orcutt's paper comments were made upon various related factors for avoiding noisy performance, such as resonance and transmission of sound by the vehicle frame, baffles in the gearbox to break up the noise of splashing oil, excessive backlash, and the fitting of gears on their shafts. Another question was the effect of gear-clashing with various forms of cut-away on gear-tooth ends, in reply to which Mr. Orcutt stated that this subject has not been given enough serious study. He said that gear teeth should be end-cut so as to give maximum prevention of upsetting action along the tooth flanks and top when clashing, this upsetting action resulting in noisier performance. There was also considerable discussion on the degree of lubrication obtained between gear teeth, with oils of light and heavy consistency, the efficiency of the gears with these various oils and the degrees of noise experienced in their use, due to splashing. Earle Buckingham referred to tests he had made which indicate that power loss in gears is proportional to their speeds rather than to the kind of oil used, and that this loss is due mostly to the dragging of the gears through the lubricant. He also stated that these losses have been determined for various oil-levels in the gearbox and that the more efficient arrangement of the gear shafts is to locate one above the other.

HIGH EFFICIENCY OF GROUND GEARS

Mr. Orcutt supplemented his paper by stating that determinations made by the National Physics Laboratories in London indicate that the efficiency of ground gears is as high as 99.6 per cent, while it may be as low as 80 per cent or even less for poorly cut gears. Major E. G. E. Beaumont, also a distinguished guest from England, reviewed briefly but interestingly his investigations with regard to prevention of noise in the gears on a fleet of about 45 motor-trucks and 15 makes of passenger-car, in which he found that much can be accomplished by inserting flexible connections in the power-transmission system and in having not too close fits between mating parts. With regard to the cut-away on the ends of gear-teeth, he felt that probably much better results will be had by giving a full rounding tooth-end, both vertically and horizontally with respect to the axis of the tooth, rather than to cut only a bevel or to round the corners and top edge of the tooth, as is now common practice.

In reply to other questions and suggestions submitted during the general discussion, Mr. Orcutt stated that the commercial factors in gear design and manufacture in America and abroad are about the same, but that in general the automobile engineers should im-

prove gears. With regard to gear grinding, he felt that form-wheel grinding is probably best but that the subject is one of much discussion. On clearances, he said that fits should be as close as possible without danger of seizing, and that 0.0005 in. is practicable in most work especially when on spline shafts. It was also his opinion that pure eccentricity is not very effective so far as noise is concerned if the gears are correctly cut and ground. Written discussion was presented by P. L. Tenney and A. B. Cox, raising mainly the points that were covered by the general oral discussion.

The paper on Simultaneous Inspection and Correction of Gears in Production, by Charles H. Logue and R. B. Fehr, was read by Mr. Logue, while Mr. Fehr gave a description of the apparatus as the illustrations accompanying the paper were projected. By means of the process, spur and helical gears are corrected to give a high degree of uniformity in spacing and profile so that the gears become practically interchangeable. They acquire a "crown face" which enables them to run with unusual quietness under practical conditions. This is essentially an inspection-correction process, as it automatically finds and eliminates the errors.

The lap is the important item in the process. It is of chilled cast-iron, gray cast-iron, or type metal, and is made by casting in a mold around a steel chill cut to approximate the gear to be corrected but has a face-width several times that of the gear. The lap looks like a wide-faced internal gear.

The gear-correcting machine is of relatively simple construction and performs three main functions: (*a*) it provides reciprocating motion for the gear; (*b*) it causes mutual pressure between the faces of the gear teeth and the lap; (*c*) it advances the gear one tooth with respect to the lap at the completion of every cycle so as to assure uniformity of spacing and contour.

PROMINENT PERSONALITIES AT THE TRANSMISSION-PRODUCTION SESSION

D. D. Ormsby (Center), Chairman; Charles H. Logue and R. B. Fehr (Upper Left and Right), Coauthors of the Paper on Simultaneous Inspection and Correction of Gears in Production; Perry L. Tenney and Earle Buckingham (Lower Left and Right), Who Presented Prepared Discussion on the Orcutt and the Logue and Fehr Papers

In the discussion following the paper, it was emphasized by Mr. Fehr that the process is a *gear-correcting* and not a gear-cutting process. He said that the gears are expected to come within the limits customarily used, and that no claim is made for removing a large amount of stock economically, although stock can be removed if time enough is taken. An important feature is that the gears are not finished all over at one time. Supposing that 100 gears are to be corrected, they are put through the process 100 ft. at a time and are put through again and again until the required amount of stock has been removed. This is called "multiple-series" lapping and, in this manner, the contours of the gears put through are maintained within very close limits of that of the average of the gears being worked upon. If one gear were put through again and again until completed, there would be a tendency for it to become more positive or more negative. If the lap or gear happened to be of somewhat variable hardness, that would be evident. But, when the gears are put through for not more than 100 to 200 ft. at a time, Mr. Fehr said that the contour can be maintained uniform.

Motor Transportation Methods

Uptodate Canadian Motorcoach Operation and Development of Haulage Discussed

LESSONS from the motorcoach operation of the Toronto Transportation Commission were given by the superintendent of the Gray Coach Lines, James L. Smith, in the first paper of the Transportation Session, Thursday morning, of which F. C. Horner was chairman. Comfortable vehicles, cleanliness, care for the rider's comfort, and selection of operators were the important points brought out in Mr. Smith's paper. Luxuries that reduce the carrying capacity of the vehicle are to be avoided unless the fare can be increased to make up for the loss entailed. Since 1925, all coaches purchased by this line have been powered with six-cylinder engines and equipped with pneumatic tires. Pneumatic tires also were fitted to vehicles that were in service with solid tires.

For sightseeing service, university students are especially trained as guides. They have been an improvement over the guides used in the old system. Chartered work has been very profitable, largely because it is done at hours other than those at the peak of traffic. It has been found advisable to select drivers carefully for this work. If possible, an official sees the party off, and an inspector accompanies a party requiring several coaches.

In the interurban transportation described by Mr. Smith, the Gray Line coaches travel to cities as far away as Buffalo and Hamilton. Mutual arrangements have been made for selling tickets over other lines to almost any point. Helpful details in this business have been suitable terminals, with helpful employes, and timetables, information on connections, and booklets.

In the discussion, Mr. Smith was asked to suggest reasons for unprofitable operation of many motor-coach lines. He laid especial emphasis on the importance of neat appearance of the vehicle and the driver. In the Gray Line service, young men, usually substitutes, are taken from the street-car work. They have become accustomed to contact with the public and are pleased to change from the street-cars to more interesting work. One trouble mentioned was that the small operator sometimes invests in too expensive a vehicle.

Personal problems and vehicle-earning figures were discussed in some detail; also general conditions of motorcoach and street-car operations. Mr. Smith does not recommend abandoning trolley tracks in cities, but believes that motorcoaches can be used in the smaller cities to better advantage than installing new trackage.

Chairman Horner mentioned that a single motorcoach terminal in New York City has sold tickets to 3500 passengers in one Sunday, some of the tickets reading as far as the Pacific Coast. Mr. Smith reported that interline tickets to New York City have just been put on sale in Toronto, and

CHAIRMAN AND SPEAKERS AT THE TRANSPORTATION SESSION

F. C. Horner (Center), Chairman; James L. Smith (Right) of the Gray Coach Lines, Who Presented a Paper on Motorcoach Operation; and R. A. C. Henry (Left), of the Canadian National Railways, Who Spoke of the Relations of the Motorcoach, the Motor-Truck and the Railroad

six were sold during the first day. By mutual arrangement, tickets are sold over other lines without commission, and this plan promises to be quite profitable.

I. A. E. President Speaks

Cooperation in Transportation was the subject of the next paper, which was presented by Major E. G. E. Beaumont, President of the Institution of Automobile Engineers, in England, who referred to a plea he had previously made for cooperation among the various manufacturers' associations of the world. He feels that the stress of competitive selling may cause price reductions that will be disastrous to producers and ultimately react unfavorably upon distributors and purchasers.

Railroads in England as well as in the United States are experiencing the effects of competition with road transportation, and must determine the true relative fields of rail and highway systems.

One of the basic difficulties of cooperation is lack of convincing information regarding costs and possible savings. While England has an Institute of Transportation, no progress has been made that can be compared with the coordinated rail and highway transportation that has been developed by the New York, New Haven & Hartford Railroad. However, the Great Western Railway has employed road vehicles as feeders for about 25 years, and this activity is being increased for both passengers and freight.

Comparative costs for motor-trucks were tabulated on the bases of 250 miles and 400 miles of operation per week. The importance of adequate accounting-systems was stressed, and attention was drawn to the fallacy of low first-cost of the vehicle at the expense of increased maintenance-cost. A plea was made for vehicles having all wearing-parts renewable without replacing the main components of the chassis.

Legislation in England lags behind engineering developments, said Major Beaumont, and this has resulted in an almost continuously tolerated infraction of the laws in regard to limitation of wheel loads and tire construction, over-all dimensions, turning circles, and speeds. New legislation promises to remedy this condition.

How Transportation Is Developing

R. A. C. Henry, director of the Bureau of Economics of the Canadian National Railway, presented the last paper of the Session. He stated that it would be wrong to think that the railroad service of today can be compared with that of 20 years ago; still, the development of highways has been many times greater. Attention was called to the influence of transportation on the settlement of the country. Early settlements in both Canada and the United States followed the navigable waters, because of the ease of original access and the convenience for transportation of products.

On the average, 20 years ago, Canadians traveled by rail only 51 miles per year. Today the average mileage has risen to 134. There has been a similar increase in per capita freight transportation. Among the motor-truck problems referred to by Mr. Henry are those of taxation and regulation of trucks engaged in common haulage or operating for hire. Many methods of taxation are now in effect, but little has been done in regard to the regulation of the business.

In closing, Mr. Henry stated that, before permitting public-vehicle operation, due consideration should be given to any existing agencies. When existing carriers can render a similar service to that proposed, or when their efficiency would be impaired, such new service should not be permitted. The public should not undertake to support two transportation agencies where one will suffice; but where additional service is necessary, its development and operation should not be hindered by undue restriction or taxation. Transportation of the highest possible quality, at the lowest possible cost, must be the keynote of our future prosperity. Each new agency must take its proper place in the general transportation scheme, and in so doing it must work in cooperation with the existing facilities to serve the best interests of the public and to provide for industrial and economic advancement.

Following the presentation of Mr. Henry's paper there was a discussion of the last two papers, which included data on operation of motorcoaches and motor-trucks in Great Britain.

Col. Charles Clifton

REGRETFUL announcement is made of the death, June 21, of Charles Clifton, aged 74, chairman of the board of directors of the Pierce-Arrow Motor Car Co., Buffalo, and one of the pioneers of the automotive industry. His demise followed an illness of only a week at his home in Buffalo. His wife, a son and daughter survive him.

Colonel Clifton was born in Buffalo, Sept. 20, 1853, and received his education in the public schools. He was the son of Henry Clifton, hotel proprietor, and Elizabeth Dorsheimer Clifton. In 1872 he became a clerk in the hardware store of Sidney Shepard & Co., in Buffalo. Five years later he was employed in the passenger department of the Erie Railroad at Buffalo and 2 years later he became a clerk for the Buffalo Grape Sugar Co., leaving it to become general manager for Colgate Gilbert, Buffalo starch manufacturer. Again he changed his employment, 2 years later, joining the Ball, Lewis & Yates Coal Mining Co., of Buffalo, as treasurer.

In 1897, Colonel Clifton began the work that absorbed him for the rest of his life when he became secretary and treasurer of the George M. Pierce Co., of Buffalo, of which he was treasurer at its reorganization in 1909 as the Pierce-Arrow Motor Car Co. He retained his office as treasurer until 1916, when he was elected to the presidency of the company. He became chairman of the board in 1919.

When the National Association of Automobile Manufacturers was dissolved in 1904 and the National Automobile Chamber of Commerce was organized, Colonel Clifton was chosen as president of the new body. He remained its president until March 2, 1927, when he resigned and was named honorary president and honorary director of the organization he had headed for so long a time.

Colonel Clifton acquired his military rank in the course of 12 years' service in the New York National Guard. During the World War, he was president of the Allied War Relief of Buffalo, and also president of the Buffalo Branch of the Fatherless Children of France. For his efforts in the latter cause, he received the insignia of the Legion of Honor.

An active interest in civic projects was evidenced by Colonel Clifton and he was particularly interested in city planning. Suggestions were made by him to the authorities of New York City, Chicago, Detroit, New Orleans and other municipalities as to methods of avoiding highway congestion in connection with city-planning projects. He was a director of the Marine Trust Co., of Buffalo, president and trustee of the Buffalo General Hospital, and president and director of the Buffalo Fine Arts Academy.

Colonel Clifton was elected an Associate Member of the Society in 1917.

William R. Strickland, whose nomination for President for the 1929 administrative year was announced at the Summer Meeting.

Chronicle and Comment

Passing of Colonel Clifton

THE passing of Col. Charles Clifton is an event of great moment and much sadness in the industry. In view of his long service as President of the National Automobile Chamber of Commerce, he was in a sense the titular head of the industry during many years. In this service he was untiringly generous in giving counsel and helpful advice in supporting the whole fabric of the industry on the basis of high principle. Colonel Clifton was a strong supporter of the Society and it mourns his loss.

Report of Nominating Committee Announced

THE nominations for officers of the Society and the Councilors for the administrative year beginning with the 1929 Annual Meeting were announced by B. B. Bachman, chairman of the Nominating Committee, during the Grand Ball at the Summer Meeting. The list of the consenting nominees follows:

For President, W. R. Strickland, assistant chief engineer, Cadillac Motor Car Co., Detroit.

For First Vice-President, Edward P. Warner, Assistant Secretary of the Navy for Aeronautics.

For Second Vice-President, representing Motor-Car Engineering, O. C. Berry, motor engineer, Buick Motor Co.

For Second Vice-President, representing Tractor Engineering, E. N. Sawyer, works manager, Cleveland Tractor Co.

For Second Vice-President, representing Aviation Engineering, W. B. Stout, Detroit.

For Second Vice-President, representing Marine Engineering, V. W. Kliesrath, vice-president, Bragg-Kliesrath Corporation, Long Island City.

For Second Vice-President, representing Stationary Internal-Combustion Engineering; J. B. Fisher, chief engineer, Waukesha Motor Co., Waukesha.

For Councilors, W. T. Fishleigh, engineer, Ford Motor Co.; O. A. Parker, president, Parker Wheel Co., Cleveland; and James A. Moyer, director of university extension, Commonwealth of Massachusetts, Boston.

For Treasurer, C. B. Whittelsey, president, Hartford Rubber Works Co., Hartford.

The members of the present Council who will hold over as members of the 1929 Council are W. G. Wall, as Past-President, and Councilors E. W. Templin, J. W. White and F. G. Whittington.

The Nominating Committee, which this year held its organization meeting during the Annual Meeting as a result of the revised regulations governing the Nominating Committee, was composed of the following:

Buffalo Section, Donald Cox, representative, J. W. White, alternate; Chicago Section, Lee Oldfield, representative, H. F. Bryan, alternate; Cleveland Section, Eugene Bouton, representatives, M. R. Wells, alternate; Dayton Section, Rodger J. Emmert, representative, V. G. Apple, alternate; Detroit Section, W. T. Fishleigh, representative, B. J. Lemon, alternate; Indiana Section, Daniel C. Teetor, representative, F. F. Chandler, alternate; Metropolitan Section, S. R. Dresser, representative, George Round, alternate; Milwaukee Section, John J. Balsom, representative, W. S. Nathan, alternate; New England Section, Albert Lodge, representative, no alternate chosen; Northern California Section, no representative and no alternate chosen; Pennsylvania Section, B. B. Bachman, representative, no alternate chosen; Southern California Section, W. M. Britton, representative, Charles H. Paxton, alternate; Washington Section, A. W. S. Herrington, representative, C. H. Warrington, alternate; members-at-large, A. J. Scaife, Cornelius T. Myers and G. Walker Gilmer, Jr.

The by-laws of the Society provide for the organization of a special Nominating Committee. If organized, the special Nominating Committee shall on or before Nov. 15 present to the Secretary of the Society the names of the candidates nominated by it for the elective offices next falling vacant, together with the written consent of each candidate.

National Meetings Announced

THE Council has definitely confirmed the time and place for the following Society meetings:

Western Aeronautic Meeting—Sept. 13 and 14, Los Angeles
Transportation Meeting—Oct. 17 to 19, Newark, N. J.
Production Meeting—Nov. 22 and 23, Detroit
Eastern Aeronautic Meeting—Dec. 6 and 7, Chicago
Annual Dinner—Jan. 10, 1929, New York City
Annual Meeting—Jan. 15 to 18, 1929, Detroit

The technical programs for these meetings are now being arranged by the Technical Committees that have been appointed by the Meetings Committee. Preliminary announcements of the meetings will appear in early issues of THE JOURNAL. Members who are interested primarily in the several fields will also be kept informed regarding the preliminary plans.

Suggestions as to technical papers for presentation at any of these meetings will be greatly appreciated by the Meetings Committee of the Society and the Technical Committees for the individual meetings.

Slade Representative at Louvain Memorial

AT the dedication ceremonies of the new Louvain Library in Belgium on July 4, the Society was represented by Arthur J. Slade, Member since 1907, formerly of New York City but now of Paris, France.

American engineers have a peculiar and intimate interest in the ceremonies, as the funds for the rebuilding of the library were contributed by American citizens and those for the carillon in the tower were given by the engineers of the United States for the making and installation of the 48 bells and a clock as the first memorial to nearly 2300 American engineers and engineering associates who gave their lives in the World War.

Nearly 3000 members and friends of engineering societies of the United States have contributed $67,000 toward the cost of the memorial which will exceed $80,000, leaving $13,000 still to be raised and forwarded through the United Engineering Society, 29 West 39th Street, New York City.

Progress and Safety in Aviation[1]

By Hon. Edward P. Warner[2]

IT is not many years since representatives of the aeronautical industry used to gather for the purpose of exchanging commiseration and wondering what was to happen next. The future was, we were all sure, bright somewhere, but we were not sure how far ahead on the horizon it lay. But in the last 2 years we have seen a very distinct change.

The airplane is definitely established as a vehicle of transport and of other commercial purposes in peace or in case the unhappy necessity of war arises. Not least among the developments of the last two years that have signalized the changing point of view of the aircraft industry and of the aeronautical engineering profession has been an increased interest in standardization activities, which have been carried on with such notable success by the Society in the automobile industry for many years past.

We cannot rest on our oars. Progress will continue as the airplane becomes better known and appreciated. The demand for development will grow automatically, but something can be done to accelerate this progress. We can hope for definite improvement along certain lines; for greater economy, for greater reliability—I should perhaps say far greater in each case—and, among other things, for greater safety.

On the subject of safety in aviation there are several points of view. Certainly all of us who have been in a position where we have had to keep a close check on the records of safety or of hazards over years past will agree that the hazard is now small. It is far smaller than was generally supposed only a few years ago, and is smaller, I suspect, than the general public yet supposes. But I think that we shall all agree, also, that we can hope for still further improvement and that we shall never be justified in saying that airplanes are safe enough, or that any other form of machinery or transport is safe enough, so long as any accidents at all occur.

I have occasionally heard it urged by enthusiasts that it is a mistake to talk about safety; that we should take safety for granted; that when we speak of the necessity for study of that factor we imply that the airplane is not safe enough now, and we scare away those who might be disposed to use it. I am sure there are very few if any among the engineers who have sympathy with that view, because, if there is one thing that every member of the engineering profession must learn and act upon, it is to face the facts and never to mislead himself; to recognize things as they are and then to seek to proceed to some more desirable condition.

There are also different kinds of safety. There is that safety which results from care in maintaining and operating equipment and which is dependent upon the perfect functioning of the human element, upon the avoidance of any human error, either in the operation of the airplane in the air or in taking care of it upon the ground. There is also that kind of safety which we might regard as the ultimate ideal, which is as nearly as possible entirely independent of the human element. This kind of safety results from the development of equipment that is, so far as can be accomplished, independent of special skill in the operator.

We attained the position long ago of being able to say that no accidents occur without a cause and that, if everything were always taken care of properly, there need be virtually no accidents. Very, very few have to be classed as unavoidable. We are progressing now toward the second stage, in which the equipment is taking over to an increasing extent the rôle of the special skill of the operator; but it is possible to do something to accelerate this progress, and it is to this purpose that the Guggenheim Safety Competition, inaugurated by the Guggenheim Fund for the Promotion of Aviation, is directed.

The Guggenheim Safety Competition has set up specifications upon which the engineer may work in the endeavor to make progress toward a specific kind of improvement in his product, designed to lead directly to the design of safer aircraft. To paraphrase the words which Colonel Lindbergh used in referring to the offering of the Orteig prize, after his return from Europe following his successful transatlantic flight, it serves as a challenge to those engaged in aeronautical work, a challenge which few may expect will be met. But it does more than that. It dramatizes safety, calls it to the attention of the lay man.

It is easy to overlook what has been accomplished in making the airplane safer and the present standards of performance, because it is always more interesting and more exciting to talk about something positive than about something negative; and safety is, in a sense, negative. What we seek is the absence of accidents. We want to say "no accidents," and the Guggenheim Safety Competition is presenting a means of making known, not only to us in the aeronautic field but to the newspaper reader, how far we can go along this road.

It is very important, in inaugurating a competition of this kind, that the rules should be right. It is easy to draw a set of rules for a contest which will do more harm than good, and will direct effort in pernicious paths. When the trustees of the Guggenheim Fund set out to inaugurate this competition they sought far and near for the counsel of all those who might be expected to have information of value to offer, and then they proceeded to coordinate and digest what they had received. In all of that work, from the first day when the competition was decided upon, down to the present, they have had, and from now on through its course they will have, invaluable counsel and assistance.

[1]From an address at the Detroit Section, Aeronautic Division Meeting, April 17, 1928.

[2]M.S.A.E.—Assistant Secretary of the Navy for Aeronautics, City of Washington.

Some Aspects of the Guggenheim Safe-Aircraft Competition

By ALEXANDER KLEMIN[1]

DETROIT SECTION AERONAUTIC DIVISION PAPER — *Illustrated with* DRAWINGS

HEREIN are set forth the performance requirements that must be met by airplanes that compete successfully for the award offered in the safe-aircraft competition and the characteristics which the aircraft must have to achieve the maximum of 200 points required to win. The author then discusses the requirements, other than those of performance, which are necessary in the design of a satisfactory commercial airplane having the required degree of safety. These include stability in normal flight, ability of the pilot to maintain control in case of engine failure, ability to recover from violent disturbances of equilibrium, controllability through a wide range of flight, maneuverability in restricted space, and maneuverability on the ground.

Although the author is acting as one of the technical advisers in the competition and has been associated with the framing of the rules, his comments herein are purely an expression of his own views.

After discussing and analyzing the length of landing run, it is stated that it is fairly clear that aerodynamic means alone will not suffice to reduce this below 100 ft. and that wheel brakes must be employed, in which case it seems not to be impossible. Alternative methods of landing, as by the steep slow glide, the two-point landing at high speed, the gentle glide and three-point landing, and the slow steep glide with the airplane nose well above the horizontal, are discussed.

Regarding stability in normal flight, it is shown that a large degree of lateral stability can be secured by appropriate use of dihedral and large vertical-fin areas, and the author indicates a hope that designers will take up seriously the study of this problem from the point where it has stood since the death 14 years ago of a brilliant English experimenter. The theory of longitudinal action at the stall, and of its control to prevent a spin, are analyzed mathematically. A theory of the cause of a spin is deduced therefrom and half a dozen suggestions for control of the longitudinal conditions at the stall are offered.

A seeming antagonism of the requirements of the competition, to prevent the stall and to obtain the stalled glide, is pointed out but is reconciled upon reflection that an airplane which cannot be stalled voluntarily may become stalled involuntarily and it will then be difficult to bring the craft out of the stall quickly; hence a machine should be stable against the stall yet be capable of being stalled.

In conclusion, the author discusses briefly the rules covering the test of ability to maintain control in case of engine failure and with the controls free. These relate to the use of wing slots and flaps other than automatic, and the point is made that, if the contestant desires to make use of these safeguards against stalling, it is reasonable to ask that the climb test be made with them in use.

THE minimum performance-requirements of the Daniel Guggenheim Safe-Aircraft Competition are as follows:

(1) Minimum flying-speed, 35 m.p.h.
(2) Minimum gliding-speed. 38 m.p.h.
(3) Top speed, 110 m.p.h.
(4) Initial climb, 400 ft. per min.
(5) Landing run, 100 ft.
(6) Approach over an obstruction 35 ft. high and coming to rest 300 ft. from the base of the obstruction
(7) Take-off in 300 ft.
(8) Take-off over an obstruction 35 ft. high in a distance of 500 ft. from base of obstruction
(9) Flattest glide, 8 deg. to the horizontal
(10) Steepest glide, 16 deg. to the horizontal, with an air speed of less than 45 m.p.h.

The aircraft achieving the maximum of 200 points[2] must have the following characteristics:

(1) Minimum speed in level controlled flight, 30 m.p.h.
(2) Minimum gliding-speed, 32 m.p.h.
(3) Maximum speed, 130 m.p.h.
(4) Landing run, 60 ft.
(5) Approach over an obstruction 35 ft. high and coming to rest 150 ft. from the base of the obstruction
(6) Take-off in 75 ft.
(7) Take-off over an obstruction 35 ft. high in a distance of 240 ft. from base of obstruction

In two articles[3] the author made a study of the minimum performance-requirements of the competition and showed that these can be met by an airplane of refined design in which some device, such as the Handley-Page slot, flaps, or tandem wing, is utilized for increasing the maximum-lift coefficient. With a maximum-lift coefficient of 0.005, a loading of 7½ lb. per sq. ft. is permissible.

REQUIREMENTS OTHER THAN PERFORMANCE

The rules of the competition call for a useful load of 5 lb. per rated horsepower of the engine, adequate structural strength, and in general a satisfactory commercial design. The remaining requirements, other than those of performance, stress the importance of:

(1) Stability in normal flight
(2) Ability to maintain control in case of engine failure

[1] M.S.A.E.—Professor of aeronautical engineering, Daniel Guggenheim School of Aeronautics, New York University, New York City.

[2] See THE JOURNAL, May, 1928, p. 596.

[3] See Notes on the Guggenheim Safety Competition, *Aviation*, Jan. 30, 1928, p. 246, and Feb. 7, 1928, p. 314.

(3) Ability to recover from violent disturbances
(4) Controllability through a wide range of flight
(5) Maneuverability in restricted territory
(6) Maneuverability on the ground

Length of Landing Run

Engineers have questioned the possibility of a landing run of 100 ft. John R. Cautley[4], in a letter to *Aviation*[5], criticizes the requirement as follows:

> The recommendation of the Bureau of Standards, which has been adopted all over the Country for automobile braking, calls for brakes to be able to stop a passenger-car in 50 ft. from 20 m.p.h. This is equivalent to a deceleration of approximately 9 ft. per sec. per sec. At 35 m.p.h., the indicated beginning of the landing of a ship as required by the Safety Competition, the above deceleration would require approximately 140 ft. to stop, without taking into consideration the sustention value of the wings from 35 m.p.h. down. The maximum deceleration I have ever been able to record with two rear-wheel brakes has been slightly over 12 ft. per sec. per sec. The maximum with two front-brakes only has been approximately 14 ft. per sec. per sec., the front wheels giving the greater effect, due to the shift of the center of gravity during deceleration.
>
> At 35 m.p.h., a deceleration of 12 would cause a stop in 109 ft.; a deceleration of 14, a stop in 94 ft. It would seem from these figures that a landing from 35 m.p.h. to a stop in 100 ft. is impossible unless some means of retardation is added to that of wheel brakes. This is due largely to the sustention effect of the wings during the first part of the landing run.
>
> Furthermore, the maximum decelerations recorded in automobiles have been on clean concrete. Unless the tests are carried out on a similar surface, the coefficient between tire and ground is likely to be considerably less than that for concrete, which would result in a still further increase in the landing run.
>
> I am a great believer in brakes for airplanes but I do not want anyone to expect them to perform miracles. I await your comments on this with considerable interest.

Mr. Cautley's criticism deserves careful consideration. At low speeds the wing drag is far greater than the parasite drag, so that the over-all L/D (lift-drag ratio) of the airplane depends largely upon the L/D of the wing. When a wing with rear flap, or a slotted wing with rear flap, is employed to secure high maximum-lift and low landing-speed, the L/D at maximum Ky (lift) runs between 4 and 6, for wind-tunnel values[6]. With the clean and efficient airplanes that are likely to be designed for the competition, and in view of the scale effects that are certain to be present, it is unlikely that an over-all L/D of less than 5 is to be relied upon at the attitude of maximum Ky. It is possible, of course, to go beyond the maximum Ky point and then work with considerably lower values of L/D; but it may then be necessary to set the aircraft down at uncomfortably high angles of incidence, and the landing speeds increase as the landing attitude goes beyond the attitude of maximum Ky.

The coefficient of friction, μ, varies widely for different types of field. From the scanty data[7] available, it would appear that μ can be taken on an average as 0.1.

Assuming that the landing speed is 35 m.p.h., which is 3 m.p.h. less than the gliding speed required; the L/D at landing is 5; and $\mu = 0.1$, the length of run is found to be 284 ft. when calculated from the formula[8],

$$\text{Length of landing run} = \frac{(L/D)\,V_o A^2}{2g\,[1 - (L/D)\,\mu]} \cdot \frac{\log_e \frac{1}{(L/D)\,\mu}}{} \qquad (1)$$

where

V_o = the initial speed, calculated in feet per second
e = eccentricity of application of load
g = base of natural logarithms
μ = the tractive coefficient

With an L/D of 4, the length of landing is 250 ft., and with an L/D of 3 it is 210 ft.

The effect of varying V_o is much more pronounced, since decreasing the speed from 35 to 30 m.p.h. brings a run of 284 ft. down to one of 209 ft.

It is fairly clear, however, that aerodynamic means alone will not suffice to reduce the landing run below 100 ft., and that wheel brakes, as distinct from air brakes, must be employed.

In using wheel brakes, the question arises as to what coefficient can be assumed for locked wheels. G. H. Dowty[9] states that, in a series of tests on road surfaces with four-wheel brakes, μ varied between 0.46 and 1.3, with an average value of 0.7. For aircraft tires, with smooth tread, the same authority deduces, from tests on landing-fields, a maximum value of 0.5 and a working value of 0.3. Lieut. Carl Green and other authorities at Wright Field have told me that a value of 0.55 may be counted upon.

Some calculations have been made on the basis of formula (1), with the results given in Table 1.

TABLE 1—CALCULATED LENGTH OF LANDING RUN

Landing Speed M.P.H.	Coefficient of Friction, μ	Over-all L/D of the Plane at Landing Attitude	Length of Landing Run, Ft.
35	0.3	5	164
35	0.5	5	124
32.8	0.5	4	100
30	0.5	4	83.5

We must consider whether, with a value of μ equal to 0.5 and the machine making a three-point landing, it is possible to apply the brakes with full action and still prevent nosing over. This condition is illustrated by the diagram, Fig. 1. For equilibrium, $\mu = \tan(\alpha+\beta)$, where α is the angle between the vertical through the center of gravity, with the machine in a horizontal position, and the line from the center of gravity to the point of contact of the wheels with the ground, and β is the angle between the ground and the line from the wheels to the skid. If $\mu = 0.5$, $(\alpha+\beta) = \tan^{-1} 0.5 = 26.6$ deg. If $\alpha = 17$ deg., which is now customary when brakes are used, and $\beta = 12$ deg., there is no danger of overturning even with full application of the brakes, unless a landing is made in very muddy and broken ground, in which case nosing over may occur even without application of the brakes.

The deceleration will not be uniform, since, when the machine first lands, the weight will be borne largely by the wings and the decelerating force will be smaller than when the brakes take charge later in the run. When the brakes are the preponderating factor, the deceleration will be 16.1 ft. per sec. per sec.

Mr. Cautley is right in assuming that to stop in 100 ft. will be difficult and uncomfortable when starting

[4] M.S.A.E.—Bendix Brake Co., South Bend, Ind.
[5] See *Aviation*, Feb. 27, 1928, p. 533.
[6] See *Aviation*, Jan. 30, 1928, p. 250.
[7] See *Aviation*, Jan. 30, 1928, p. 246, and Feb. 6, 1928, p. 314.
[8] See THE JOURNAL, April, 1920, p. 231, and TRANSACTIONS, vol. 15, part 1, p. 560.
[9] See Wheel Brakes and Their Application, *Flight*, Dec. 29, 1927.

from a speed of 35 m.p.h., but the Bureau of Standards recommendations have to take the comfort of passengers into consideration somewhat more than is necessary for an aircraft in a strictly emergency landing. It would seem that a landing run of 100 ft. is difficult but not impossible to secure.

Some obvious suggestions in this regard are:

(1) To land directly from a stalled steep glide, so that a portion of the velocity along the path is vertical and there is a large landing-shock which helps to shorten the run
(2) To use "wing-spoilers" after landing
(3) To depress the flaps to an excessive angle after landing, so as to reduce the lift of the wings and increase their drag

Steep Slow Glide

There has been considerable discussion as to the value and possibility of the steep glide at 16 deg. to the horizontal, that is, 1 in 3½, at an air speed of less than 45 m.p.h. with complete control. This requirement has reference to the case in which a pilot has to make a landing in a small emergency field surrounded by high obstacles. He has, theoretically, the choice of several methods:

First, to glide down on a steep path, nose down, at a fairly high rate of speed, and flatten out rapidly a short distance from the ground. In the steep glide he can lose altitude without much forward motion, and his machine will be in perfect control. Difficulties arise when flattening out. If he changes the incidence to the angle of maximum Ky, he may zoom to some extent, which is not helpful. If, on flattening out, the machine does not zoom, it may still have excess speed for the high-angle attitude, and float quite a long way close to the ground, which is again not helpful.

Or he may flatten out to a moderate angle of incidence and make a two-point landing at a high rate of speed, trusting in his ability to maneuver on the ground and in his brakes to bring him to rest safely within the confines of the small field. With a two-point landing, violent use of the wheel brakes is not so safe, and particularly in rough ground this procedure does not seem desirable.

Or he may convert his steep glide into a gentle glide, flatten out to a three-point landing attitude, and make a most desirable landing, but again find himself too near the end of the field.

Or he may resort to such maneuvers as coming down in a tight spiral, fish-tailing, or side-slipping. Such maneuvers by a skilled pilot may be entirely safe, but to my mind they do not constitute desirable commercial operation.

Finally, we have the method, which is contemplated by the rules, of a slow steep glide, beyond the stalling point, with the nose of the airplane well above the horizontal. The exact reference in the rules is as follows:

> *Steepest Glide.*—The aircraft shall be able to glide with all power switched off so that the angle between the flight path and the horizontal is not less than 16 deg. During this test the air speed shall not exceed 45 m.p.h.; the aircraft must demonstrate that all the controls are definitely effective throughout the test, and that it can land safely out of this glide from a useful altitude.

[10] See *Aviation*, Feb. 6, 1928, p. 316.

In the Notes on the Guggenheim Safety Competition[10] previouly referred to, preliminary calculations have shown that a steep glide, at 16 deg. to the horizontal and at a little more than 38 m.p.h., is possible with a loading of 7.5 lb. per sq. ft., with the use of a front Handley-Page slot, a rear flap depressed 20 deg., and an incidence of 23.39 deg. The steep glide must, apparently, be executed somewhat beyond the angle of the maximum Ky point to get sufficiently low L/D values.

If the aircraft is under complete control at 16 deg. to the horizontal, it is gliding on a path of 1 in 3.5, with a vertical-velocity component of $38 \times \sin 16$ deg. = 10.5 m.p.h. The pilot must land the craft "out of this glide from a useful altitude" which has been fixed tentatively at 20 ft.

Nosing Down

The peculiarity of this glide beyond the maximum Ky is that, to check the vertical velocity, the angle of incidence must actually be diminished or the airplane

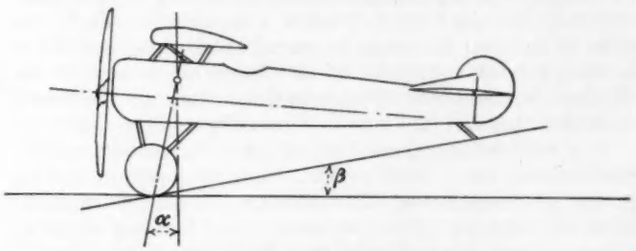


Fig. 1—Diagram of Landing Attitude

For Equilibrium, μ Equals the Tangent of the Angle, α, between the Vertical through the Center of Gravity, with the Airplane in a Horizontal Position, and the Line from the Center of Gravity to the Point of Contact of the Wheels with the Ground, Plus the Angle, β between the Ground and the Line from the Wheels to the Tail-Skid. If $\mu=0.5$, $\alpha+\beta=26.6$ Deg., and if $\alpha=$ 17 Deg., Which Is Now Customary When Brakes Are Used, and $\beta=12$ Deg., There Is No Danger of Overturning, Even with Full Application of the Brakes, on a Smooth Hard Field

nosed down. But, unfortunately, there is little leeway in increasing the Ky. Thus, in the example previously quoted, the Ky was 0.00482, and the maximum Ky of the slotted-wing and rear-flap combination was only 0.00512. If the pilot chose to glide down at 45 m.p.h. on a path steeper than 16 deg. to the horizontal, he would have even a larger vertical velocity to contend with, and the possible variation in Ky would still be small. Nosing the plane down slightly, therefore, will not decrease the vertical landing-shock appreciably. The craft will have to be nosed down considerably till a normal glide is achieved, then flattened out for the perfect three-point landing. It is hardly conceivable that all this can be done in descending from an altitude of 20 ft. Granting even that the average vertical velocity is only 5 m.p.h., the time to execute this complicated maneuver will be only some 2.7 sec., and, as a matter of fact, when nosing down into the normal glide there may be increase rather than decrease of vertical velocity. At the same time, to make the "useful altitude" considerably more than 20 ft. defeats the very purpose of the rule, which is intended to foster an aircraft capable of gliding steeply above some such obstacle as a tall clump of trees.

One is led to the conclusion that the general flying objective and the literal objective of the rule will be met by a machine which noses down only slightly from its attitude on the steep path, and strikes the ground

in a three-point attitude with a vertical velocity of 10 m.p.h., or a couple of miles less if the gliding speed is 7 or 8 miles less than the 38 m.p.h. previously considered.

The Department of Commerce Handbook requires a height of free drop for shock-absorbers of 24 in. which corresponds to a vertical speed of 7.75 m.p.h.; and, with this free drop, the landing factor must not exceed 6.5. It is clear from this that a direct landing from a steep, stalled glide will need a large travel in the landing-gear shock-absorber mechanism, even if the oleo or eleo-pneumatic type of shock-absorber is used.

Where Handley-Page front slots alone are used, the chassis will have to be somewhat higher than for a normal machine, to provide a large angle of incidence on landing. If front slots are used in conjunction with a rear flap, the chassis will be of normal height.

Maintaining a Stalled Steep Glide

From the preceding paragraphs the conclusion may safely be drawn that a stalled steep glide will be of value in making landings in restricted territory. There is, however, the problem of achieving such a glide in which it is necessary to maintain an angle of incidence somewhat beyond the angle of maximum lift.

In a modern airplane having the center of gravity either ahead of or just at the foremost position of the center of pressure on the wings, the horizontal tail-surfaces must carry a downward load for equilibrium at any normal flight-condition. With the stabilizer set to trim for cruising speed, a strong diving-moment is supplied by the tail surface at a large angle of incidence, and a maximum upward movement of the elevator is frequently insufficient to bring the machine to equilibrium at a high angle of incidence. It is then necessary to move the stabilizer leading edge far down, as well as to raise the elevator. Nothing is specifically stated in the rules of the competition to forbid such double action.

But even when the stabilizer has its leading edge pushed down and the elevator is turned up, it is not easy to achieve very high angles of incidence, particularly as, beyond the stalling angle, the center of pressure on the wings moves rapidly back. The British have given us experimental evidence in this regard. R. M. Hill and H. L. Stevens state[11] that, with the Standard Avro, a glide at 20-deg. incidence could be steadily maintained with the stick hard back and the stabilizer leading-edge down. When it was desired to reach higher angles of incidence, they had to alter the center of gravity by using two tanks capable of holding 11 gal. of water each, one near the center of gravity and one near the tail, connected to each other by a large pipe having a cock under the control of the pilot and a jettison valve for use in case of emergency. Eventually, a gliding angle of just below 45 deg. was obtained, with an L/D of just above 1.

Since varying the position of the center of gravity is not possible in the competition tests, it will be necessary, to achieve a steep glide, either to (*a*) provide a large stabilizer-adjustment, and a very rapid one, or (*b*) increase the proportion of elevator to total horizontal area.

Increasing the total area of the tail surface may not be advisable, since it may make the machine too stable in normal flying. A backward position of the center of gravity, undesirable in normal flying, is desirable from the point of view of the steep glide.

If a steep glide is achievable by combined action of stabilizer and elevator, the aircraft should be very stable on the glide, since the center-of-pressure motion on the wing is stable beyond the burbling point. The British report mentioned above states that the Avros, with far-back position of the center of gravity, though longitudinally unstable in normal flight, were longitudinally stable when stalled, and one of the two airplanes would actually glide "hands off" in this condition.

In this stability in the stalled glide lies, incidentally, another argument for elevators of large area in proportion to the total horizontal area. The pilot may wish to "unstall" rapidly, and in such a case he should have powerful elevators.

Effects of Lift-Increasing Devices

The question arises whether airplanes equipped with lift-increasing devices for the purposes of the competition present a greater or a lesser difficulty from the point of view of equilibrium on the stalled glide.

Let us consider first the case of a wing fitted with a front Handley-Page slot alone, with which it is desired to secure a slow steep glide. In both the airfoil with a front slot and the airfoil without a front slot the center of pressure moves back after the angle of maximum Ky is reached. With the swiveling slot open, the center of pressure at maximum Ky is likely to be 2 per cent of the chord farther back than with the slot closed[12]. With the type of slot which is varied by moving an auxiliary airfoil forward, the center of pressure at maximum Ky with the slot open will be either the same as with the slot closed or else 2 per cent of the chord farther forward. This is indicated by some unpublished tests at New York University and by recent thesis work of Messrs. Baisley and Coonradt. These changes in the center of pressure are relatively unimportant. It is important, however, that with a slotted wing the lift coefficients are higher than with an unslotted wing, and the backward movement of the center of pressure then becomes more powerful in relation to the tail surfaces provided. There is also this difference, that the slotted airfoil reaches its maximum Ky at angles of incidence some 5 to 6 deg. higher than the unslotted airfoil. A stabilizer adjustment which may cause the stabilizer to have a down load at the stall position of the unslotted wing may give an upward load at the stall position of the slotted wing. Therefore, in securing the stalled glide with slotted wing, it will probably be necessary to (*a*) increase the total horizontal tail-surface area, (*b*) give the stabilizer still more adjustment, and (*c*) increase the area of the elevator as a proportion of the total horizontal tail-surface area.

When a rear flap is used in conjunction with a front slot, the angle of maximum Ky remains practically that of the basic wing, but the center of pressure moves back in the neighborhood of 5 to 6 per cent, even if the front slot is of the type that moves forward. Therefore, the obtaining of a stalled glide will be just as difficult with a slot and flap combination as with a front slot alone.

In general, where very slow speeds are contemplated,

[11] See Notes on Stalled Flying, British Reports and Memoranda No. 963.

[12] See Slotted Wings, by F. Handley-Page, International Air Congress, 1923.

the relative effect of gusts is greater, and greater elevator-control becomes advisable. It has been suggested that tail surfaces having more camber on the lower than on the upper side would help to achieve stalled gliding; but this would be at variance with the requirements of stability against the stall.

Another argument for the use of very powerful elevators lies in a further competition rule which states:

> The aircraft will further be required to demonstrate that if the elevator control is pulled in toward its maximum extent at the moment of switching off and held in that position, the aircraft will remain under control, not get into any violent or dangerous maneu vers, and descend on a steep-glide path at a speed not exceeding 40 m.p.h.

Such a test would be difficult to pass if the elevators were not powerful enough to maintain a high angle of incidence without stabilizer adjustment, although 40 m.p.h. does not mean so steep a glide as 16 deg. to the horizontal.

Experience with Stalled Gliding

Anthony H. G. Fokker, in a paper[13] presented before the Institution of Aeronautical Engineers, writes:

> Take as an example the DV-11 (a Fokker design). It is quite possible to fly this machine with the engine on or off and the control stick as far back as possible, and remaining perfectly controllable, both in the rudder, ailerons and elevator. Flying with the engine on, the control stick must be pressed forward again when it is desired to climb, thus clearly proving that flight has taken place in the second region. The same is the case with engine off and the control column pulled fully back. The machine will then plane down at a very steep angle, and against a headwind she will appear to be standing still, descending vertically. The vertical velocity has been ascertained to be 12 to 14 ft. per sec., while the horizontal speed was only 60 ft. per sec., giving a gliding angle of 4½ to 1, or 12 to 14 deg. (The best gliding angle of the machine is 1 in 8.3.)
>
> The machine is perfectly controllable, and, provided the wind is not too gusty, it is possible to land like this, the tail striking the ground first and the landing rather resembling a "pancake." During the glide the nose of the machine remains well up, the longitudinal axis of the machine making an angle of about 8 to 9 deg. with the horizon. The angle of incidence at which the machine descends is thus 20 to 23 deg. The landing is naturally rather bumpy and hard on the wheels and axle, but it is quite possible, and easy too, and is even recommended to the military pilots in cases where they get caught in a ground fog covering the airdrome. However, it is of course better for the machine not to land in this fashion, in which case the control stick must be pushed forward to stop the vertical velocity. It is a way of flying which is very popular among the military pilots, who call it "cycling," because of the very small speed.

It seems probable from this that machines were available several years ago which could be kept on a steep stalled glide and made to land directly from such a glide.

More recent experiments by Captain De Haviland on the Moth equipped with slotted ailerons indicate that a pancake landing from a height of 10 ft., simulating a misjudged landing, can be made without breaking up the machine. In a stalled glide from 200 ft., made with the same machine at a vertical velocity of 10 m.p.h., the chassis was undamaged but the oleo struts went through the landing-gear. Captain De Haviland emerged unscathed, although the fuselage broke into three pieces. Some reinforcement of the fuselage would have made the direct stalled landing quite feasible.

Stability in Normal Flight

The longitudinal-stability requirements are such as can be met readily by any modern airplane, and the method of test in which the speed is varied by a displacement of the elevator, which is subsequently released, is well known and needs no comment.

The general-stability clause reads:

> The aircraft to be capable of flying at any air speed from 45 m.p.h. to 100 m.p.h. and at any throttle opening of the engine or engines, with all controls left free, for a period of not less than 5 min. in gusty air.

The term "all controls left free" does not preclude the use of an adjustable vertical fin, or some form of rubber-cord adjustment of the rudder bar, or even of a "bungee" for the aileron control. It would be most unreasonable to expect an airplane to fly all controls free without some trimming device to counteract the engine torque. Granted the use of some such trimming device, the test becomes quite reasonable.

Designers have known for many years that a large degree of lateral stability could be secured by the appropriate use of dihedral and large vertical-fin areas. The British in particular have done a great deal of theoretical work on the subject, which is well understood. Particularly under the influence of military requirements, constructors have preferred controllability to a high degree of lateral stability. They have also feared to introduce much lateral stability for fear of too ready a response to gusts near the ground. Yet rather early experiments by the British Royal Aircraft Factory[14] proved that excellent lateral stability could be secured without impairing the other flight qualities of an airplane. It is most interesting to quote from the results of these experiments on the once well-known, slow but dependable R.E-1 and B.E-2:

> *R.E.*-1 *Rolling-Stability Experiments.*—Dihedral angle, 177 deg. 15 min. Nov. 25, 1913. Weather, calm. The wing-flap controls were entirely abandoned and the airplane was flown 7½ miles with two turns without their use. The rudder was used for steering.
>
> Nov. 26, 1913. Weather, light wind. The evolutions of airplane bore out the theoretical expectations. Disturbance by a gust was followed by side-slip toward the low side, which brought the dihedral angle into effect, righting the machine.
>
> In both the above experiments the recovery from a roll seemed rather slow, and it was decided to double the amount by which the wings were bent up.
>
> Dec. 2, 1913. Dihedral angle, 174 deg. 35 min. Weather, fresh wind. The airplane was flown a distance of 3 miles against a wind, of which the Pyestock record shows variation from 23 to 39 m.p.h., without making any use of the lateral controls.
>
> *R.E.*-1 *Complete-Stability Test.*—Dihedral angle, 173 deg. 35 min. March 10, 1914. Weather, squally, with snowstorms and clear intervals. The airplane was flown from Long Valley, Aldershot, to Froyle near Alton, and also from Froyle to Fleet, distances of 6¾ and 8 miles, without the use of wing-flaps or elevator. The wing-flaps were left free as usual and the elevator was locked. The flying was very comfortable.

[13] See Development of Cantilever Wings, Institution of Aeronautical Engineers, Nov., 1923.

[14] See Lateral Stability, by Mervyn O'Gorman, with Experiments by E. T. Busk; British Reports and Memoranda No. 133.

The tests described show that a very considerable measure of lateral stability can be used without impairing the flying qualities of the machine or making it uncontrollable. Difficulties in handling on the ground in high winds have not exceeded those experienced with warping machines, though they would, of course, do so with very exaggerated dihedral angles, but it is doubtful whether angles beyond those tried can be used with advantage to the stability.

It would be a wonderful outcome of the competition if the designers would take up seriously the work which the death of the brilliant young Busk set back for so many years.

Stability Tests Not Mentioned in Rules

It may be of interest to mention that, as a result of careful study, some additional tests of stability have been included other than those specifically mentioned in the rules. These include

(1) Roll by means of ailerons, while the elevators are used to keep the machine from pitching and the rudder is used to keep it on a straight course after the rudder is released. Dihedral action on side-slip should restore the machine to an even keel.

(2) Yaw by means of rudder, while the elevators are used to keep the machine from pitching and the ailerons are used to keep it on an even keel laterally. After the rudder is released, fin action in the rear of the center of gravity should restore the machine to a straight course.

These tests will be described more fully in a Flight Test Manual for the competition, which will shortly be issued by the Guggenheim Fund for the Promotion of Aeronautics.

Lateral Control at the Stall

Lateral control at the stall has been so well covered in recent publications that little need be said on the subject. Only a word of warning is necessary that, even with slotted wings and rear flaps, the possibility of autorotation and the spinning nose-dive is only postponed to a higher angle. In the same way, loss of lateral control and the introduction of unfavorable yawing moments may not be precluded by the use of slotted ailerons but only postponed to a higher angle of incidence.

Theory of Longitudinal Action at Stall

In pilots' experience with the stall, in which imperfect aileron-control has resulted in a falling off on one wing and a subsequent spin, the pure longitudinal action at the stall has been masked. The theoretical discussions frequently advanced have been imperfect, because writers have restricted themselves largely to qualitative considerations and have not attempted an exact dynamic analysis. From a study of many unpublished tests at New York University, and in particular of a thesis by Marco A. Urtis and Frederick J. Knack[15], the following conclusions have been drawn by the writer:

(1) Even when trimmed for steep climb, modern airplanes having the center of gravity far forward are stable at the stall.

(2) With the center of gravity far forward, the tail surfaces carry a down load, even when trimmed for steep climb; therefore they are not themselves stalled when the wings stall.

(3) The elevators do *not* cease to be effective at the stall. Turning the elevators down will increase the righting or diving moment even at very large angles of incidence for the main wing, partly because the tail surfaces are initially carrying a down load, and partly because of the downwash. Of course, the elevators will be less powerful than at high speeds.

(4) The righting moment or diving moment persists far beyond the stall of the main wing.

(5) The backward movement of the center of pressure on the wings is a help rather than a hindrance to "unstalling".

(6) With the modern longitudinally stable machines having the center of gravity at 30 per cent of the chord or thereabouts, there is not much choice between airplanes of many different designs of tail planes and elevators.

With all these favorable factors, it may be asked why planes should ever get into difficulties at high angles of incidence. It is best, at this stage, to write down the three equations of motion, with special reference to Fig. 2, and the following terminology:

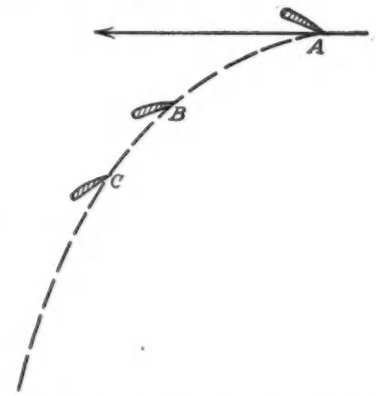


Fig. 2—Diagram of Longitudinal Motion in a Glide

T Is the Angle between the Chord of the Wing and the Horizontal, *C* Is the Angle between the Tangent to the Path and the Horizontal; and *i* Is the Angle of Incidence between the Chord of the Wing and the Path at Any Instant

W = weight of airplane, in pounds
K = radius of gyration about the transverse axis through the center of gravity, in feet
l = distance from the center of gravity to the elevator hinges, in feet
i = angles of incidence between the chord of the wing and the path at any moment, expressed in degrees
T = angle between the chord of the wing and the horizontal, in degrees
C = angle between the tangent to the path and the horizontal, in degrees
L = lift of the entire airplane
D = drag of the entire airplane
V = velocity along the path, in foot-seconds
t = time, in seconds
w = angular velocity in space, in degrees per second
M = moment about the center of gravity, positive when tending to stall the airplane
M_q = damping moment due to pitching velocity

Resolving along the flight path and perpendicularly

[15] See thesis, Longitudinal Stability of an Airplane at Angles of Attack Beyond the Critical Angle, New York University, June, 1927.

to the flight path, and taking moments about the center of gravity, we obtain the following equations:

$$\frac{W}{g}\cdot\frac{dV}{dt} = W\sin C - D \tag{2}$$

$$\frac{1}{57.3}\cdot\frac{WV}{g}\cdot\frac{dC}{dt} = W\cos C - L \tag{3}$$

$$\frac{1}{57.3}\cdot\frac{Wk^2}{g}\cdot\frac{d^2T}{dt^2} = -M_t - M_q w \tag{4}$$

and since $i = C - T$, $T = C - i$

$$w = \frac{dT}{dt} \tag{5}$$

In an analytical solution, it is best to consider small intervals of time, during which V is constant and certain derivatives also are considered constant. Then, for a given interval of time

$$i = i_o + \triangle i$$
$$C = C_o + \triangle C$$
$$T = T_o + \triangle T$$
$$V = V_o$$

We can also write

$$\begin{aligned}\text{Sin } C &= \sin(C_o + \triangle C)\\ &= \sin C_o \cos \triangle C \cos C_o \sin \triangle C\\ &= \sin C_o + \cos C_o \frac{\triangle C}{57.3}\end{aligned}$$

$$\begin{aligned}\text{Cos } C &= \cos(C_o + \triangle C)\\ &= \cos C_o \cos \triangle C - \sin C_o \sin \triangle C\\ &= \cos C_o - \sin C_o \frac{\triangle C}{57.3}\end{aligned}$$

$$D = D_o + \left(\frac{dD}{di}\right)\triangle i$$

$$L = L_o + \left(\frac{dL}{di}\right)\triangle i$$

$$M = M_o + \left(\frac{dM}{di}\right)\triangle i$$

The equations of motion then become

$$\frac{W}{g}\cdot\frac{dV}{dt} = W\left[\sin C_o + \cos C_o\frac{\triangle C}{57.3}\right] - \left[D_o + \left(\frac{dD}{di}\right)\triangle i\right] \tag{6}$$

$$\frac{1}{57.3}\cdot\frac{WV_o}{g}\cdot\frac{dC}{dt} = W\left[\cos C_o - \sin C_o\frac{\triangle C}{57.3}\right] - \left[L_o + \left(\frac{dL}{di}\right)\triangle i\right] \tag{7}$$

$$\frac{1}{57.3}\cdot\frac{Wk^2}{g}\cdot\frac{dw}{dt} = -\left[M_o + \left(\frac{dM}{di}\right)\triangle i\right] - M_q\cdot w \tag{8}$$

Now we must try to get D and L in terms of the lift coefficient and drag coefficient of the airplane. For short interval of time, let

$$L = K_y A V_o^2$$
$$D = K_x A V_o^2$$

Then

$$\frac{dL}{di} = AV_o^2\left(\frac{dK_y}{di}\right)$$

$$\frac{dD}{di} = AV_o^2\left(\frac{dK_x}{di}\right)$$

Considering the damping, we have for the damping moment

$$M_q = A_{tail\ surfaces}\cdot(\text{length of moment arm})\cdot V_o^2\cdot\left(\frac{dK_{y\,(tail)}}{di}\right)\triangle i \tag{9}$$

$$= A_t\cdot l\cdot V_o^2\left(\frac{dK_{y\,(tail)}}{di}\right)\left(\frac{l\cdot w}{V_o}\right) \tag{10}$$

$$= \left[A_t\cdot l^2\cdot V_o\frac{dK_{y\,(tail)}}{di}\right]\cdot w \tag{11}$$

Therefore

$$M_q = A_t\cdot l^2\cdot V_o\cdot\left(\frac{dK_{y\,(tail)}}{di}\right) \tag{12}$$

Substituting these expressions in the three equations as above, we get

$$\frac{W}{g}\cdot\frac{dV}{dt} = W\left[\sin C_o + \cos C_o\frac{\triangle C}{57.3}\right] - \left[D_o + AV_o^2\left(\frac{dK_x}{di}\right)\triangle i\right] \tag{13}$$

$$\frac{1}{57.3}\cdot\frac{WV_o}{g}\cdot\frac{dC}{dt} = W\left[\cos C_o - \sin C_o\frac{\triangle C}{57.3}\right] - \left[L_o + AV_o^2\left(\frac{dK_y}{di}\right)\triangle i\right] \tag{14}$$

$$\frac{1}{57.3}\cdot\frac{Wk^2}{g}\cdot\frac{dw}{dt} = -\left[M_o + \left(\frac{dM}{di}\right)\triangle i\right] - A_t\cdot l^2\cdot V_o\left(\frac{dK_{y\,(tail)}}{di}\right)\cdot w \tag{15}$$

Hence we have,

$$dV = g\left[\sin C_o + \cos C_o\frac{\triangle C}{57.3}\right]dt - \frac{g}{W}\left[D_o + AV_o^2\left(\frac{dK_x}{di}\right)\triangle i\right]dt \tag{16}$$

$$= \left\{g\left[\sin C_o + \cos C_o\frac{\triangle C}{57.3}\right] - g\left[\frac{D_o}{W} + \frac{AV_o^2}{W}\left(\frac{dK_x}{di}\right)\triangle i\right]\right\}dt \tag{17}$$

$$dC = \left\{\frac{57.3\,g}{V_o}\left(\cos C_o - \sin C_o\frac{\triangle C}{57.3}\right) - \frac{57.3\,g}{WV_o}\left[L_o + AV_o^2\left(\frac{dK_y}{di}\right)\triangle i\right]\right\}dt \tag{18}$$

$$dw = \left\{-\frac{57.3\,g}{Wk^2}\left[M_o + \left(\frac{dM}{di}\right)\triangle i\right] - \frac{57.3\,g}{Wk^2}\left[A_t\cdot l^2\cdot V_o\left(\frac{dK_{y\,(tail)}}{di}\right)\right]\cdot w\right\}dt \tag{19}$$

To get a physical interpretation of these equations, it is best to consider the case in which the airplane has been flying horizontally and steadily at a large angle of incidence, and the engine suddenly fails. Then,

$$dV = -\left\{\frac{g}{W}\left[D_o + AV_o^2\left(\frac{dK_x}{di}\right)\right]\triangle i\right\}dt \tag{20}$$

The loss of speed will depend mainly on (a) the lift-drag ratio and (b) the value of $\frac{dK_x}{di}$. If the wing is such that at stalling the drag increases rapidly, there will be a rapid deceleration. Again we see that

$$dC = \left\{-\frac{57.3\,g}{WV_o}\cdot AV_o^2\cdot\left(\frac{dK_y}{di}\right)\triangle i\right\}dt \tag{21}$$

Positive increase in C will depend mainly on $\frac{dK_y}{di}$. Again, $\frac{dw}{dt}$ will increase with the inherent stability of the plane and be opposed by the damping moment. From these considerations we can fomulate a theory on the following lines (See Fig. 3):

When the engine fails while the wing is at a high

angle of incidence, there is an immediate loss of speed. This produces a loss of lift, which loss is increased by a negative value of $\frac{d K_y}{di}$. The path in space curves downward. The stabilizer and elevator tend to nose the machine down, but they may not turn it in space fast enough to unstall; hence the machine may descend on a steep path with the nose well down and yet remain stalled, giving always an opening for a spin.

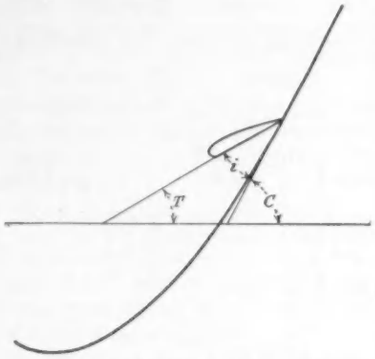


FIG. 3—DIAGRAM OF A NOSE DIVE

This Elucidates the Theory Formulated from Mathematical Formulas that, When the Engine Fails While the Wing Is at a High Angle of Incidence, Loss of Speed Follows Immediately, Producing a Loss of Lift, Which Is Increased by the Tendency of the Stabilizer and Elevator To Nose the Machine Down. Similar Considerations Apply When Climbing Steeply and the Engine Fails, but the Conditions Are Aggravated

When the machine is climbing steeply and the engine fails, similar considerations apply, only the conditions are aggravated.

So far as longitudinal conditions at the stall are concerned, the following are beneficial therefor:

(1) Large inherent stability, with the center of gravity far forward
(2) Large and powerful elevators
(3) Slightly more camber on the upper surface of the stabilizer than on the lower surface
(4) Large horizontal control-surfaces, but short-coupled so that the damping does not impede recovery from the stall
(5) Thrust line below the center of gravity, to facilitate nosing down of the airplane when the engine stops
(6) Wings of the Joukowski type, with large camber and large well-rounded leading edge, so that the K_y curve is practically a straight line beyond the angle of maximum K_y.

The slotted airfoil, particularly when automatic, provides a treble safeguard against stalling, in that it stalls at a higher angle of incidence than the unslotted airfoil, that it stalls at a lower speed for the same wing-loading, and that, owing to the higher angle of incidence at the stall, the inherent diving moment is greater.

The slotted airfoil in combination with a flap provides only a double safeguard; it stalls at approximately the same angle of incidence as the basic airfoil, but the stall occurs at a lower speed, and the depression of the flap causes a backward movement of the center of pressure on the wing.

SEEMING ANTAGONISM OF REQUIREMENTS

Constructors of aircraft have often claimed that they have built machines which will not stall or spin. To attain such a purpose, the obvious thing to do is to have a machine which is very stable at high angles of incidence and has comparatively small elevator-power.

To obtain steep stalled gliding it seems necessary to have elevators powerful enough to overcome the stability at high incidence.

There is seeming antagonism between the two requirements. Reflection will show, however, that a machine which cannot be stalled voluntarily by the pilot may become stalled involuntarily, as in the case of engine failure on a climb, and it will then be difficult to unstall rapidly because of small elevator effectiveness.

A machine meeting the competition requirements should be both stable against the stall and yet able to be stalled when required.

TEST OF ABILITY TO MAINTAIN CONTROL

The rules read:

> The aircraft will be required to demonstrate that, in case of complete engine failure (all power being switched off), it will take up a steady gliding attitude when all controls are left free from the moment of switching off the engine or engines.

This rule deserves study in conjunction with the following note in Appendix III of the rules:

> The use of devices by which the aerodynamic characteristics of the aircraft can be varied during flight will in general be permitted, subject to the following conditions:
>
> If the device is not automatic and requires operation by the pilot, the operating control must be simple, quick in action, and conveniently placed, and must not involve appreciable physical effort by the pilot. If, in the opinion of the Fund, the safety of the aircraft is prejudiced by dependence on the operation of such device in emergency, the aircraft may be called upon to pass any or all of the safety tests at one fixed setting of the device, in which case the Rate-of-Climb Test under "Qualifying Requirements" must be passed at the same fixed setting of the device.

The likeliest condition for the stall occurs when the machine is climbing steeply and the engine fails. If the machine has its steepest climb at an angle somewhat greater than the angle of maximum climb, it will then be fairly near to its stalling point. If either slots or flaps other than automatic are used, and if the contestant wishes to make use of the safeguard to provide against stalling, it is quite legitimate to ask that the climb test be passed with slots or flaps in use.

The same considerations apply to the rule:

> The aircraft will further be required to demonstrate that if the elevator control is pulled in toward its maximum extent, at the moment of switching off, and is held in that position, the aircraft will remain under control, not get into any violent or dangerous maneuvers, and descend on a steep-glide path at a speed not exceeding 40 m.p.h.

In this case the slow glide is likely only with the slots open and the flaps depressed.

THE DISCUSSION

IVAN H. DRIGGS[16]:—A point occurs to me regarding the recovery from a condition of engine stoppage on a steep climb, which I have observed in flying the TA-5, built by the Dayton Wright Co. for the Army. That airplane was balanced very far forward on the chord, about 26 per cent, I believe, and it was driven by a Wright Whirlwind engine. In case of engine stoppage, the airplane nosed down very, very quickly of its own accord, and it was very difficult to fly at any throttle setting, for the simple reason that it was necessary to

[16] Driggs Aircraft Corporation, Lansing, Mich.

take enormous loads on the elevators. The thought occurs to me that that may have been due to the fact that the slipstream over the tail surfaces was causing a large portion of their reaction and the immediate stoppage of that slipstream reduced the load on the tail surfaces sufficiently to cause an immediate diving moment. One solution of that problem might be to balance the airplane a little forward on the chord, thus increasing the longitudinal stability, which probably is dependent more on the position of the center of gravity than on any other single factor.

PROF. ALEXANDER KLEMIN:—I think that is very reasonable. I was considering that the conditions of power off and power on would not affect the balance so much that an airplane would be designed for power off and power on, but in the case you mention I can see that the airplane would become tail-heavy with power on and then would be trimmed by raising the nose of the stabilizer, so that when the power was cut off the airplane would go into a dive and would not stall.

CONDITIONS AFFECTING RECOVERY FROM STALLED DIVE

QUESTION:—What is the conventional relation between the center of gravity and the center of effort in an airplane, as for example the Ford trimotor?

QUESTION:—In what way, if any, does the condition of stall, during which the corrective effort does not catch up with the path of flight, increase the stability of the airplane?

PROFESSOR KIEMIN:—The stall occurs in spite of the stability of the airplane. If an airplane were stable at the stall it would tend to catch up with the path of flight, but they are never stable enough to do so. Mr. Driggs has made the valuable suggestion that, if we have this difference in power-off and power-on condition, the diving tendency with the power off can actually be increased. It might not be so pleasant at other times to have too much variation of the power-off and power-on.

MR. DRIGGS:—That particular machine was flown at McCook Field for four or five years, and I have heard a number of aviators say it was a very satisfactory craft except that it was a little stiff longitudinally, which may be a desirable characteristic for an airplane which is going to approach the foolproof characteristics. It is necessary to build a ship very stable to meet the rules of the competition, requiring it to be flown hands-off for a certain period of time in gusty air; and, after all, longitudinal stability is just as important as lateral stability. We have to increase the longitudinal stability more than the usual amount and also attain the other condition of being able to nose down quickly after an engine stoppage in a climb.

QUESTION:—Why are the bearing surfaces that support the rudder and ailerons and stabilizer so small?

PROFESSOR KLEMIN:—I think they are only relatively small. They seem to be quite adequate. I was not aware that they were small.

MAJOR R. W. SCHROEDER[17]:—We started about a year ago to build an airplane for this competition. In the course of events we asked a lot of questions among people we knew. Having served on the Rules Committee myself, I thought I understood the conditions of the competition fairly well, and set out to design an airplane but found, after about three months of investigation, that we would first better build a wind-tunnel. The last eight months have been spent in building a 3-ft. wind-tunnel so that we could get ready to build the plane. We are not ready yet to ask questions about the airplane but would like to ask some questions about how to build a wind-tunnel.

WILLIAM C. NAYLOR[18]:—One idea occurred to me in regard to brakes. Some time ago the Department of Commerce asked that all airplane manufacturers supply the figures on landing run and take-off run of all their airplanes that have a certificate of airworthiness. On the day we made our landing-run test there was about 2 in. of snow and some ice on the field. Incidentally, the air speed also was recorded, by means of the air-speedmeter, which read 50 m.p.h. on landing; and it is surprising to note that the landing run was 325 ft. at that speed, with the wheels absolutely locked. The pilot came down and made as perfect a three-point landing as he could. Yet the minimum run we got was 325 ft. I think that checks fairly well with Professor Klemin's figure of 288 ft. at the lower landing-speed.

WILL STANDARDIZE LANDING-RUN TESTS

PROFESSOR KLEMIN:—I see the force of your point very well. I think it is the consensus of opinion of the judges, of whom Secretary Warner is one, and of the committee, that the ground conditions will have to be carefully observed. The field manager will be instructed that, unless the ground conditions correspond to some particular standard, the test either will not be run or very careful corrections will be made for the condition of the ground. I think, on the whole, it will be advisable to test all the airplanes with approximately the same ground conditions. If the ground were covered with ice, it would be impossible to reduce the landing run to 100 ft.

MR. NAYLOR:—Do the rules of the competition specify the conditions?

PROFESSOR KLEMIN:—No, but we hope shortly to issue a Flight Test Manual to place at the disposal of the entrants and which will indicate the various technical conditions.

MR. NAYLOR:—If this test were conducted at the Ford Airport, where there are cement runways, the value of μ you spoke of would be increased.

PROFESSOR KLEMIN:—All the tests will be run at Mitchel Field, and the field manager will have experimental methods at his disposal so that he can test μ when necessary and find that it does not depart from certain average conditions. We are as anxious to make the competition fair as the entrants are, and shall use every precaution to avoid any unfairness.

MR. NAYLOR:—The reason I ask this is that I also had some correspondence with the Bendix Brake Corporation and it specified that the value of μ, if I remember correctly, was 0.5 for gravel and 0.8 for concrete.

A MEMBER:—Is it not 0.5 for grass and 0.8 for concrete?

PROFESSOR KLEMIN:—That is what we figured.

EFFECTIVENESS OF LOCKED WHEELS IN STOPPING

THOMAS H. HUFF[19]:—A question has been brought out in regard to locking the wheels on landing. My impression was that better braking effect is obtained if the

[17] Stout Metal Airplane Co., Ford Airport, Dearborn, Mich.
[18] Jun. S.A.E.—Chief engineer, Stinson Aircraft Corporation, Northville, Mich.
[19] M.S.A.E.—President, Huff Airplanes, Inc., Perth Amboy, N. J.

wheels are not locked. My understanding with regard to stopping a locomotive was that it cannot be stopped in so short a distance if the wheels are locked as it can be if they are not locked but are just allowed to slip on the brake-shoes. I should think the same would apply to the airplane.

PROFESSOR KLEMIN:—My impression is, so far as all the airplane tests I have heard of and all the automobile tests go, that the coefficient will be greater with the wheels locked. I am not familiar with locomotive practice, but I am sure the difference with the wheels stopped and the wheels free is enormous, that the friction is five or six times as great when the wheels are locked.

RALPH H. UPSON[20]:—I think Mr. Huff is right. It is the common experience that automobiles can be stopped more quickly if the wheels are not locked. Of course, it is necessary to approach very near to the point of locking. If the drums are slipping in the shoes the friction is slightly less than the force necessary just to start from rest, and the energy is absorbed internally with the wheels still going round. I think it is quite correct that the braking effect actually is greater, but it is a problem how to hold the brakes at just that point.

A MEMBER:—There is not much difference on concrete between the almost-slipping wheel and the slipping wheel, because the scraping off of rubber by the concrete gives virtually the same effect as sliding the wheel. My recollection is that tests made by the Bureau of Standards showed very little difference in braking effect between the point of almost locking the wheels and locking them.

G. BETANCOURT[21]:—In the motor-car we have the front brakes and the rear brakes as two distinct problems. As we apply the rear brakes, the inertia effect of the car decreases the ground reaction at the rear wheels; therefore, the locked wheel proves clearly to be less effective than the wheel where sliding is just impending. But, if the front wheels are braked, the inertia effect of the car increases the ground reaction at the front and consequently the braking action of the front wheels up to the locked-wheel stage. In the airplane, the landing wheels are like the front wheels of the motor-car; and when they are braked the inertia effect of the plane, with its center of gravity so well forward, increases so rapidly that the pilot can increase his braking pressure considerably before he can lock his wheels; and when he finally succeeds in locking them the plane is already at rest unless the landing takes place on wet grass or mud. This makes it almost impossible to keep the wheels from becoming locked when the maximum retarding effect of the brakes is looked for, and it distinctly *appears* that the locked-wheel can be used with greater advantage than a wheel where the sliding is just impending.

COMPETITION WILL BRING OUT NEW IDEAS

WILLIAM B. STOUT[22]:—During the National Airplane Reliability Tour last year we made stopping tests with different airplanes. We had our airplane fitted with non-skid tires so they would hold the ground better, and had a 1-ton load in the cabin. The pilot landed with the wheels locked, and the distance from the place where the wheels touched to the place where the machine stopped was 185 ft. Six seconds was the official stopping time.

Regarding this competition, safety is one thing, but it is another thing to design an airplane for the manufacturer to build. We have got into the rules the specifications of an airplane for the manufacturer to build, on the assumption of the committee that when it is completed it will be a safe airplane. Even that point, I think, could be argued from as many different angles as there are manufacturers, but a competition of this kind is invaluable in bringing out new ideas, even though the airplane, when it is built, may not be safe and may have to be piloted expertly to pass the tests; it may be a trick plane having no commercial value in the form in which it then exists. Yet, from this competition there undoubtedly will come hundreds of ideas some of which, taken up by the commercial group, can be made into practical things for commercial work.

The idea of a safety competition might be left to a commitee which could say that the man who brought out an airplane construction and demonstrated it as the safest should win the prize. The decision would then be up to the committee. In this case, specifications are set up for an airplane to be built for certain performances. There is no bonus, as I understand it, for an airplane that can be landed on land or water, on mud or trees, without danger.

LOW LANDING-SPEED NOT A SAFETY FACTOR

Regarding low landing-speed, the man who does not fly believes that low landing-speed is a function of safety. I think that pilots as a body will agree that low landing-speed is *not* a function of safety. It is the ability to get into the smallest field surrounded by the highest obstacles and land on the roughest ground, on the smallest space, without getting hurt which makes the machine safe in landing. An airplane could be built that would land at 20 m.p.h. As a matter of fact, the Wrights approached closely to that in their early airplane, but if one went up in it on a day of ordinary wind-gusts he would bounce all over the sky, and the plane was in no way practical for ordinary use.

Our airplane has a wing load of about 11 lb. per sq. ft. Its minimum landing-speed is about 54 m.p.h., and our landings are, normally, made at about 60 m.p.h., I suppose, in spite of the small distance in which I said we landed with the wheels locked. Shortly after we delivered one of these airplanes in Chicago and while it was standing on the field, an 85-m.p.h. line-storm came without warning. The pilot was in his seat and three or four mechanics jumped on board, but the machine started across the field. The wind picked it up, carried it a city block, and landed it on the cross arm of a high-tension-line pole. The boys jumped out before it took off. It took them all day to get it back. An airplane having a landing-speed of only 35 m.p.h. would be as helpless in a wind of much less velocity as this one was; and any ordinary wind-gust would pick up an airplane landing at 20 m.p.h. and carry it off the field.

The average wind-gust in a storm is about 20 m.p.h. If a machine lands at 40 m.p.h. and a puff of wind hits the tail when it is landing, half the lift is lost, no matter what devices are on it or how the airplane is arranged. But if the same wind puff hits an airplane that has a 60-m.p.h. landing-speed, two-thirds of the lift is left and, with very little increase in speed, the craft and passengers are safe. It will be noticed that, in a heavy wind, the pilots do not reduce to anywhere

[20] M.S.A.E.—Chief engineer, Aircraft Development Corporation, Detroit.
[21] Draftsman, Aircraft Development Corporation, Detroit.
[22] M.S.A.E.—President, Stout Air Services, Inc., Dearborn, Mich.

near their normal landing air-speed, but come to the land at a high air-speed to have their airplanes completely under control.

These are all factors that I think enter into a commercial airplane and that differ from the idea of the competition; but I am very much in sympathy with it from the point of view of developing new ideas. I think it will be a great aid to the industry and that commercial aviation will gain a great deal from it. The ideas just advanced by Professor Klemin on stability are worth the entire effort of the competition.

Expect Devices To Regulate Landing Speed

PROFESSOR KLEMIN:—There is only one point in Mr. Stout's objection to the low landing-speed in a puff of wind that I would like to answer. We are not trying to get an airplane which is loaded 4½ lb. per sq. ft., as it would have to be if it met these conditions without some device. We expect that the machine will be loaded as heavily as practicable but will have some device which will enable the pilot to land slowly when he wants to; then, as regards gusts of wind, if the pilot thinks it is safer to land fast, there is nothing to prevent him from landing his machine up to 110 m.p.h.

With reference to the suggestion that the safest machine should be determined by a committee from all points of view, such as landing in mud and ability to have other features, no committee, unless it were composed of superhuman individuals, would be capable of judging which was the best machine. Probably it would end in a fight among the committee members. We avoided that by saying, "Let us include in the competition only those things which can be determined mathematically, and give points on those; then we shall not argue. We will ask for certain characteristics which all machines must have and which depend on the 'feel' of the pilots, but we will not give any points on those. We will give points on those things which are measurable, and we will measure them as accurately as we know how."

I think it probably is true that in the automobile the inertia effect acting at the center of gravity may put more load on the front wheels than on the rear wheels. We will take Mr. Betancourt's word that this is right, as he ought to know. But in the airplane we will have this condition, that the load on the front wheels will really be only the weight of the airplane, because the turnover tendency of the dynamic reaction, the tendency of the airplane to go ahead, will be balanced; therefore we will purposely make the balance by placing the center of gravity back. The motor-car cannot nose over but the airplane can; hence we cannot utilize the inertia effect, and therefore we shall get no extra down-load on the wheels.

Landing Angle and Braking Coefficient

A MEMBER:—I should like to ask one more question in that connection. Visualizing the magnitude of the force set up when the coefficient of friction, μ, is equal to 0.5, would that not produce a moment that would tend to nose the airplane over if the normal angle between the vertical and the line from the center of gravity to the point where the wheels touch the ground is 10 or 11 deg.? Would not that angle have to be perhaps 18 or 20 deg., putting an excessive load on the tail?

PROFESSOR KLEMIN:—I do not think it would if the airplane were landed in the three-point attitude. I am glad you raised the question because I made a calculation on it. If μ is 0.5, the angle should be about 26 deg., so the angle between the vertical and the line to the point of wheel contact will be 17 deg. when the machine is in level condition; but we presuppose that the machine will land tail down, in which case the effective angle will be increased by the angle between the wheel and the tail-skid, so altogether the angle will be about 25 or 26 deg. and a coefficient of 0.5 will just about balance.

J. M. LADDON[23]:—With reference to brakes, tests were made with an angle of 34 deg. between the axle and a vertical through the center of gravity, and the airplane would not nose over when the wheels were locked. This would mean a normal landing-angle of about 17 deg. and the same angle between flying and landing attitudes. The coefficient of friction was determined as 0.55 from a series of about 10 or 15 tests. The coefficient increased slightly on gravel, to about 0.6; on grass it was 0.55. In the early tests that were made on brakes it was anticipated that the nosing-over effect would be very serious, but it was found at once that the elevator control during the first part of the landing prevented this and, as the speed diminished, the pilot could reduce the braking. Even with airplanes having the landing-gear too far aft, there was no sudden nosing-over tendency; it was a gradual effect that could be taken care of by easing off on the brakes.

My personal opinion about the safe-airplane competition is that the man who wins will be the one who knows best how to deviate from the specification. That has been the general way in which competitions have usually been won; by picking that condition in the competition which is believed to be unreasonable and departing from it. In this particular competition I think the unreasonable element is the one Mr. Stout pointed out, the 35-m.p.h. landing-speed.

[23] M.S.A.E.—Aeronautical engineer, Consolidated Aircraft Corporation, Buffalo.

Gas Masks for Firemen

SMOKELESS powder is a great generator of carbon-monoxide gas. The first sea-battle of the World War showed the necessity for providing adequate protection for the men who were serving the guns. Chemists from Johns Hopkins University and the University of California, associated with the Chemical Warfare Service, developed a mixture of oxides which converted the fatal carbon-monoxide into the relatively harmless carbon-dioxide. This agent, which is called Hopealite in honor of both universities, has made possible the special gas-masks used by firemen in all large cities. Today more gas-masks are being manufactured for industrial workers and firemen than are being made by the Government for the protection of its soldiers.—Arthur Chapman.

The High-Speed Diesel Engine as a Competitive Power Generator

By CHARLES EDWARD LUCKE[1]

METROPOLITAN SECTION PAPER — *Illustrated with* CHARTS

HEREIN the author analyzes the Diesel oil-engine as a competitor of the steam engine and, more specifically, of the gasoline engine, in the stationary-power field and in the field of marine and land transportation.

The two bases for judging the new as against the old are, first, suitability for the purpose, and, second, the cost of performing the required service. After reviewing other fields in which the oil-engine has shown its suitability, the author considers its suitability for automotive purposes. If it is equally suitable with the gasoline engine for motor-vehicles, that type of engine which shows lower cost for power will ultimately prevail; or, if the Diesel-engine cost is sufficiently lower, this type may be adopted for certain automotive uses even though it is somewhat inferior to the gasoline engine in suitability.

The prospects of useful economic results from the automotive Diesel engine are so favorable, in the author's opinion, that almost any effort to perfect it and adapt it to the needs would be justified now. The most important reason for this conclusion is the adaptability of the engine to a great variety of liquid fuels.

No reason exists for believing there will be any substantial difference in manufacturing cost if the Diesel engine is built by the same methods and in the same quantities as the gasoline engine; hence, first cost will be in proportion to weight in pounds per horsepower. Fixed charges will be in proportion for equal life and use. Experience to date indicates that the life of the Diesel engine should be equal to or longer than that of the gasoline engine, and that service costs need be no greater.

In the matter of fuel consumption the oil-engine seems to be the more efficient, about in the ratio of 4 to 5; and this, with a cheaper fuel, means a large reduction in fuel expense per ton-mile.

Development and adoption of the oil engine have been impeded by doubt of the ability to reduce its weight sufficiently, but, after analyzing the variables that fix the weight per horsepower, the author shows that an added weight of 30 per cent, to resist the maximum cylinder pressure for its somewhat longer period, is all the weight by which this type needs to exceed that of the gasoline engine. He even intimates that it is not beyond possibility that equality of weight may be obtained in four-cycle engines and perhaps better in the two-cycle type.

Requirements as to torque, balance, flexibility and such matters are being proved by experience to be attainable, which confirms the analytical conclusion that these are only matters of engineering ingenuity and design.

There remains the difficulty of metering the fuel and properly mixing it with the necessary quantity of air for proper combustion in high-speed engines. Several solutions of this problem have been advanced and there will be others. Hence it is to be expected that there will ultimately be as many automotive Diesel engines in use as there are now successful gasoline engines.

EVERY time a new means of generating power is brought forward, or a new engine developed, it becomes necessary to appraise it, and such an appraisal must include an analysis of the economic competition with other things having a similar purpose. The new power-generator is economically in competition with all others, and the application of its power to some specific use puts that utilization into economic competition with other things having a similar purpose. This condition of competition is especially true in the field of transportation, in which the vehicle, be it ship, aircraft or car, has its character more or less defined by the motive power that forms a part of it and which has no other purpose than its propulsion.

Creation of the Diesel engine and its development into a reliable machine for generating power has put it into economic competition with other power sources for all sorts of power uses, and for each new application a critical judgment becomes necessary before adoption of the engine. Should this result in a justifiable adoption in a given case, a new train of investigation is started to determine if the thing displaced can be improved, with the possibility always that, by such improvements, it may in turn earn the right of restoration to its old place.

In judging the new in comparison with the old, there must always be a double basis: first, that of suitability for the purpose; and, second, that of cost of service. If the Diesel engine is as suitable in its characteristics for a given purpose as some other, and if at the same time it gives cheaper power, no differences of opinion can exist as to its adoption. The conclusion is equally sure against adoption if, for another purpose, the Diesel engine is less suitable and its power cost higher than for the alternative power-generator. When suitability and cost factors are opposed, however, there is always a rational doubt; and honest differences of opinion as to adoption are to be expected when the Diesel suitability is inferior with lower power-costs, or when its suitability is superior with higher power-costs, or when suitability and power costs are variable with time, place and circumstances.

Two typical examples of conditions of more or less equal suitability, one in the stationary and the other in

[1] M.S.A.E.—Professor of mechanical engineering, Columbia University, New York City.

the marine field of competition between the Diesel engine and steam power, are very helpful in considering the present problem of competition between the Diesel engine and the gasoline engine in the field of small-unit automotive-power for vehicles of the numerically larger classes, where differences in suitability rather than differences in cost have so far delayed adoption.

The first of these examples is that of generation of electric power in stationary powerplants by Diesel engines or by steam. Up to the limit of the maximum practicable size for oil engines, the suitability is equal and decision rests on power costs. Here the oil-engine powerplant requires greater capital investment than the steam plant, but, owing to the higher efficiency in the smaller capacities, the operating expenses are lower even with more expensive fuel. Omitting many details, curves of power cost in cents per kilowatt-hour, plotted against kilowatts installed capacity for both Diesel and steam, will cross somewhere. At the capacity indicated by the intersection the two systems give equal power-costs; for smaller capacities, Diesel power is cheaper, and, for larger capacities, steam power is cheaper. This is illustrated in Fig. 1, reproduced from my paper entitled Value of Efficiency in Transforming and Distributing Energy[2], by the curve for certain assumed conditions. The conclusion is that if a powerplant in a given locality is small enough, Diesel power is cheaper and Diesel engines are to be used, whereas all larger plants should be steam, or perhaps hydroelectric, with due regard to electric-transmission expenses.

The Competitive-Cost Situation

The second of these examples is that of the seagoing ship. Here, after a period of trial and error, the Diesel engine was proved to be as suitable for propulsion and auxiliary service as the older, universally used steam engine and its later-developed competitor, the steam turbine. With suitability equalized for the two, adoption rested on costs, and year-by-year accumulation of such proof of lower ship-operating costs for motorships over steamships has resulted in steadily increasing use of motorships, of which the Saturnia is a fine example. This competitive-cost situation is illustrated by Fig. 2, for one type of ship, the 10,000-ton cargo-ship with direct-coupled Diesel engines, compared with a steamship having Scotch boilers and geared turbines. This set of curves, taken from my paper entitled The Internal-Combustion Engine in Marine Service[3], shows the gross yearly return on investment plotted against days per voyage at sea, which is a measure of use per year, and it shows that the higher investment costs for the Diesel powerplant are offset by the fuel savings resulting from the higher efficiency if the ship is used enough days in the year; otherwise, as for example, short sea-trips and long port-stops, steam is cheaper.

This conclusion is in effect similar to and in confirmation of that for stationary electric generation, but a very important difference as to future stability of the situation is to be noted. While in stationary powerplants, especially those of central stations, steady and rapid improvement in efficiency has been going on with some but not a proportionate increase in investment, and an over-all efficiency as low as 12,500 B.t.u. per kw-hr. or about 27 per cent, has been reached, this has not yet been tried on steamships. Success of the motorship at sea is now having the effect of attracting the attention of marine interests to the possibilities of improving the efficiency of marine steam-plants to approach more nearly that of central stations, even if this involves an increase of investment and of machinery weight. It will be very interesting to watch this economic struggle as costs and efficiencies of steamship machinery approach motorship figures, especially since the steamship may burn coal but the motorship is limited to fuel-oil.

[2] See *Transactions of the American Society of Mechanical Engineers*, 1924, p. 1245.

[3] See *Journal of the Franklin Institute*, July and August, 1921.

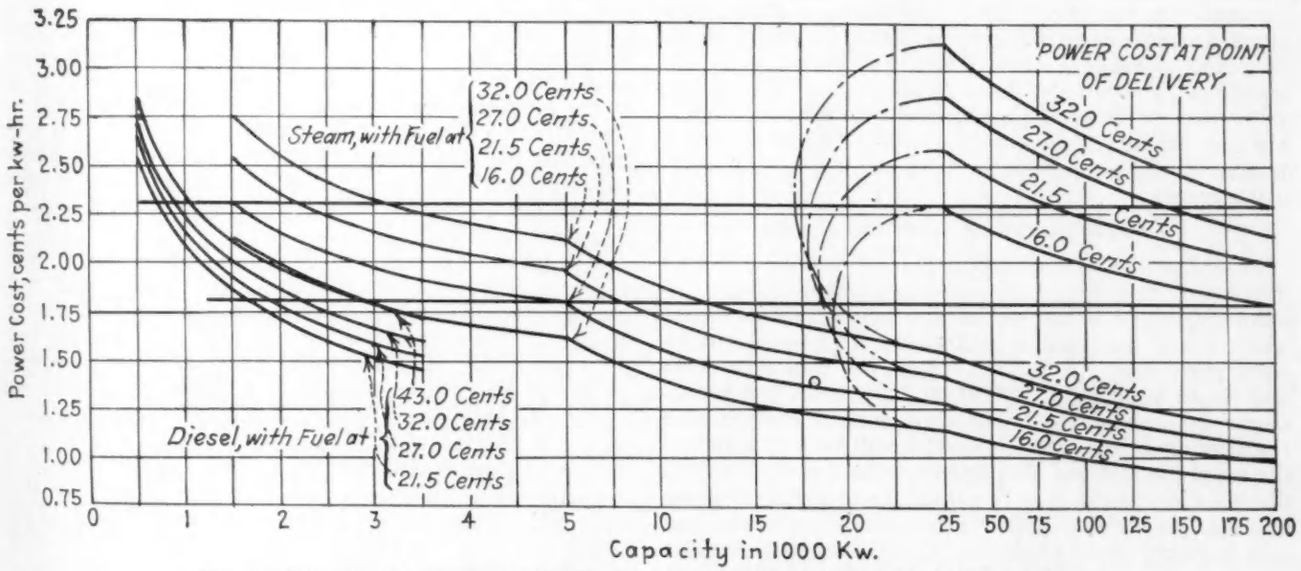


FIG. 1—COMPARISON OF TOTAL POWER COST OF STEAM TURBINES AND DEISEL ENGINES

The Curves Show the Cost of Producing Power in Cents per Kilowatt-Hour. Those at the Lower Left Give the Cost of Fuel Consumed by the Diesel Engine When Operating on Fuels at the Four Prices Shown. The Middle Curves Give the Cost of Steam Power at the Four Prices of Steam Fuel Shown. The Four Curves at the Upper Right Give the Power Cost at the Point of Delivery When the Transmission Cost Equals the Generation Cost with Steam Fuel. Steam Power Is Shown To Be Cheaper than Diesel-Engine Power for Large-Capacity Units or 15,000 Kw. or More; Small-Capacity Diesel Units Give Greater Economy

With economic history such as this now available, the competition between the Diesel engine and the automotive-type gasoline engine may be approached with less uncertainty. If equality in suitability for automotive use can be found in Diesel and gasoline engines, it will be clear that whichever gives the lower cost for power or transportation will ultimately prevail; and, if the Diesel-engine costs should be enough lower than those of the gasoline engine, perhaps the Diesel engine might still be adopted for some uses even if its suitability were somewhat inferior. Considering the enormous number of gasoline engines in use and their distribution among the boat, aircraft and automobile types of service, not forgetting the gigantic petroleum industry that is now adjusted to gasoline production, it would be hard to find a problem more worthwhile than the analysis of relative suitability of Diesel and gasoline engines for transportation services and the corresponding analysis of relative transportation costs to be expected. The future of some part of this matter of public importance, and perhaps the whole of it, is bound up in the answer to these questions.

The question is, What is to be expected of the automotive Diesel engine? And with this is the further question, Is there enough of promise to justify any considerable expenditure of time and money to convert promise to reality? My opinion is that the prospects of useful economic results from the automotive Diesel engine are so favorable that almost any effort to perfect it and adapt it to needs would be justified now.

The first and most important reason for this conclusion is found in the adaptability of the Diesel injection oil-engine to liquid fuels of great variety and source because virtually nothing matters with reference to the fuel except fluidity, assuming adequate cleanliness and non-corrosive properties. The gasoline engine requires a fuel of proper volatility to be manufactured for it, and the present situation of the automotive industry is an example of an effort to make a fuel to fit an engine. On the other hand, the Diesel engine represents a development to fit a fuel, not one fuel but any fuel that is really a clean liquid, and which may have an animal, a vegetable, or a mineral origin. No analysis is needed to foresee the economic effects of such a change, so all effort may be concentrated on other phases of the problem of relative suitability and operating costs.

Possible Parity of Cost per Pound

If similar methods of production are used and if production of Diesel and of gasoline engines is equal in quantity, there is no reason for believing that there will be any substantial difference in manufacturing costs per pound. It follows, therefore, that first costs will be in proportion to weight in pounds per horsepower for automotive Diesel and gasoline engines, and the fixed charges against operation will be in proportion for equal life and use. Experience to date indicates that, for machine design that is similar as to metal stresses, bearing pressures, speeds, heat-generation rates and such matters, there should be no differences in life for equal use that are unfavorable to the Diesel engine, and that, if anything, life conditions are more favorable to Diesel engines. For example, in oil engines there is nothing equivalent to the lubricating-oil contamination in gasoline engines. Adjustments and repairs or general servicing will be the same for all major parts; and real differences must be sought in a comparison of the fuel pump and sprayers of the oil engine with the electric ignition system, the carbureter and the heaters of the gasoline engine. The Diesel-engine designer should, and no doubt will, accept this and make his design with a view to at least equal reliability. No sound reason exists for doubting his ultimate success.

Oil Engine More Economical of Fuel

This leaves for consideration, under the heading of transportation costs, the item of fuel expense, which for some vehicles is of little consequence, while for others it is a controlling item. Fundamental considerations of thermodynamic efficiency of transforming heat into work, reinforced or confirmed by test data, lead to the conclusion that, for compressions allowable in gasoline engines and compressions best suited to Diesel engines, about equal to the maximum pressures of the former, the Diesel engine is the more efficient. For full load, in each, the fuel consumption of the oil engine should be less than for the gasoline engine, about in the ratio 4 to 5, for the best examples of each, with less departure from the best among Diesel engines than among gasoline engines. For good Diesel engines the indicated thermal efficiency established by reliable tests is

$$\text{Per cent of efficiency} = 46 - 0.033 \times \text{indicated mean pressure} \quad (1)$$

Engines not so good will have lower efficiencies, say 9/10 or 8/10 of this. For light loads, typical of ordinary automobile driving, the ratio is more favorable to the Diesel engine because of complete absence of throttling, which uses so much energy in the gasoline engine. All of this leads to the conclusion that Diesel automotive engines will have lower average fuel consumption than gasoline engines and give a substantially larger mileage per gallon; and this, with a cheaper fuel, means a very large reduction in fuel expense per ton-mile.

Doubt of Weight Reduction Impedes Development

With such strong reasons for the development and adoption of the automotive Diesel engine, the small progress made to date and the lack of encouragement offered to the pioneers who have gone ahead anyway are hard to understand. The situation probably is due to a suspicion that the Diesel engine could not meet the suitability requirements and so could not be acceptable as a substitute for a gasoline engine in any of the standard fields of application and use.

One of these old doubts, heard for many years, was concerned with the weight question. Those who had learned that the old marine Diesel engine of the Burmeister & Wain type, for example, weighed 450 lb. per hp., jumped to the conclusion that no Diesel engine could be made light enough for automotive service. For a long time no analysis was made of the prime factors, and the shock of learning that large M.A.N. submarine engines weighed 50 lb. per hp. was survived by the still vague conclusion that this must surely be the low limit. This was all nonsense, of course, and more people are now learning the elements of weight well enough to accept the statement that an automotive Diesel engine can be made to weigh not more than 30 per cent more than an automotive gasoline engine, though not many are yet ready to believe that there is no inherent reason why it may not be made actually lighter than the gasoline engine without reducing the

engine life, even if no one has so far succeeded in doing this.

Variables That Fix Weight per Pound

It can be shown that the weight per horsepower is fixed by three wholly independent variables, as follows:

$$\text{Lb. per hp.} = C \times \frac{\text{(lb. per cu. in.)}}{P \times \text{(r.p.m.)}} \qquad (2)$$

where

C = a constant of proportionality
P = mean effective pressure
Cu. in. = piston area times piston stroke times number of cylinders.

Studies of engine-metal weights prove that the weight per cubic inch is wholly a matter of machine design as to number and arrangement of cylinders and cranks, and of stresses and bearing pressures. It is independent of bore or size of cylinder, and is the same for Diesel engines as for gasoline engines of equal maximum combustion pressure, with an added weight of about 30 per cent to resist the maximum pressure for its somewhat longer period. A two-cycle engine has the same weight per cubic inch of piston displacement as a four-cycle engine, with a very small addition representing the excess of scavenger weight over that of the four-cycle valves and valve-driving gear; so the factor C above for two-cycle engines has nearly one-half the value for four-cycle engines.

The product of mean effective pressure and speed for the Diesel engine is the only remaining factor to be examined, except the general questions of suitability. These are concerned with the functioning of the Diesel engine, the will-it-work question. Will it work, not only as to fuel handling, but as needed for requirements of torque, balance, flexibility and such matters? The fact that experience is proving these latter requirements to be attainable, within service limits, by designers in one automotive field after another is confirmation of the analytical conclusion that, except for fuel handling, these are purely matters of engineering design, with, of course, a reasonable component of engineering ingenuity.

The Fuel Metering and Mixing Problem

The fuel handling is the new difficulty; the problems of pump, sprayer and connections for the accurate metering of the fuel oil per stroke, about 0.0001 of the cylinder volume, and the introduction of the metered oil in such a way as to enable all the oil to meet its required volume of air and to utilize as much as possible of the air in supporting combustion at any specified speed or range of speed. If all the air is utilized in combustion in the Diesel engine, thermodynamic analysis, again confirmed by test data, establishes the fact that the mean effective pressure will be higher for Diesel than for gasoline engines for equal cylinder charges, just as efficiency is higher for equal maximum pressures. If, however, the method of bringing the oil and air together in the cylinder is not effective enough to utilize all of the air at the required speed, or if all of the fuel does not burn at the maximum pressure, then the mean pressures will be lessened, and probably the efficiency too.

Without further analysis it becomes clear that the automotive Diesel engine will be a successful competitor of the automotive gasoline engine, in one or another of its fields of use, in proportion as the high-speed fuel-metering per stroke is done accurately and reliably done at all speeds, and then in proportion as the injection arrangements, including combustion-chamber form, are such as to utilize one-half or more of a good, big air charge to support fuel combustion at the compression or the maximum pressure. Several solutions of this part of the problem have been offered, and there will be many others as time goes on and as the needs of the situation become more clear, with increasing understanding of the economic goal and the available engineering means of reaching it. Some of these will be more successful than others and it is to be expected that these will lead, but there is room for many.

It is also to be expected that there will be as many successful automotive Diesel engines as there are now successful gasoline engines. How soon this probability will become a reality depends primarily on the encouragement offered to engineers, because, with understanding, all that is needed is support for the research and designing that must precede commercial production. Everything points to the conclusion that, sooner or later, the automotive gasoline engine must yield at least a part of the field it now dominates to the Diesel injection oil-engine.

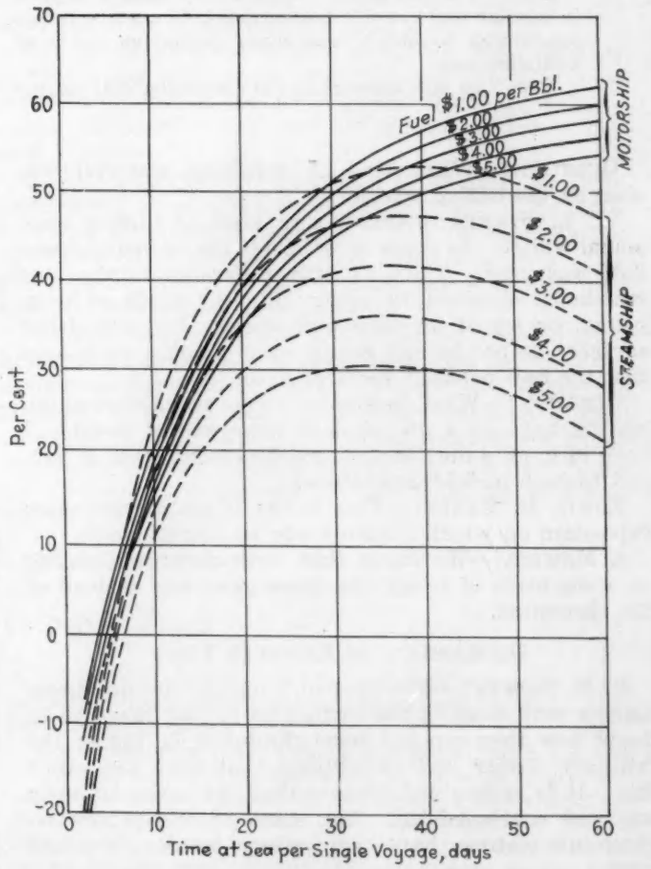


FIG. 2—COMPARISON OF GROSS EARNINGS ON INVESTMENT BY DIESEL-ENGINE SHIP AND STEAMSHIP.

Earnings Are Shown in Per Cent on Investment with a Freight Rate of $2 per 1000 Ton-Miles. Solid Lines Represent the Gross Earnings of a 10,000-Ton Direct-Coupled Motorship, and the Dash Lines Those of a Steamship Having Scotch Boilers and Geared Turbines. Both Sets Are Based on Fuel Costs Ranging from $1 to $5 per Bbl.

Protective Value of Chromium-Plate

Discussion of E. M. Baker and W. L. Pinner Annual Meeting Paper[1]

THIS paper is restricted in scope to a study of the rust resistance afforded by electrodeposited coatings of chromium alone and in combination with nickel and copper.

The appearance value of a chromium surface is well established; but chromium alone has little protective value for outdoor exposure.

The protective value of a composite coating depends largely on the protection afforded by the underlying coats.

Increase in the amount of chromium deposited on nickel and copper, up to a thickness of 0.00001 to 0.00002 in., increases the protective value, but a further increase of thickness up to 0.00027 in. of chromium decreases the protective value to almost the result obtained with no chromium.

These conclusions are supported by data presented in tabular and graphic forms, and indicate the proper procedures to obtain maximum protective value at minimum cost.

Questions and answers in the discussion deal mainly with the kind of buffing wheel and compound used in polishing the underlying surfaces; the length of life of nickel and of chromium-plating; and the success obtained with chromium-plating on plug and other gages, on edged tools, burnishing tools, running bearings and piston-pins. A suggestion is made that tests of durability of the plating be made by exposure to weather as well as by the salt spray; and that an undercoat of brass instead of copper may reduce the cost by requiring less chromium.

Pressures are the limiting factor, it is said, in the use of this kind of plating on cutting edges and on bearings; and the length of life of plated gages depends on the number of threads for which a gage is made, and like conditions. One company is making 25,000 chromium-plated piston-pins daily, and another, which has put out between 550,000 and 600,000 plated fanshafts and combination water-pump and fan shafts, has had no trouble with them and finds that they give much better service than the former hardened shafts.

QUESTION:—What kind of polishing material was used on the buffing wheel?

W. L. PINNER:—Almost any kind of buffing compound will do. In these experiments the ordinary sewed buff was used. There is little difference in the rust resistance obtained in using different kinds of compound, or sewed or loose buff-wheels; but unpolished surfaces do not by any means have the rust resistance that the best polished surfaces have.

QUESTION:—What protective value would chromium-plating have on a die when it receives hot metal? I have in mind a die for pressure die-casting that is subject to high metal-temperatures.

EDWIN M. BAKER:—That is one phase of chromium deposition on which I have made no investigation.

A MEMBER:—We found that, with chromium-plating on a die made of brass, the brass gave way instead of the chromium.

DESIRABILITY OF EXPOSURE TESTS

R. H. SHERRY[2]:—The present situation of chromium-plating with most of the companies is that they are in doubt how they can put some chromium on top of the ordinary copper and nickel-plate that they use every day. It is rather unfortunate that the series of tests was not continued and that some of the papers on chromium-plating have not given results obtained with weatherd bars as well as with salt spray. I have tried a few of these and have found that, of a duplicate pair of bars, one gives a wonderful salt-spray test but the other, left out for a year, shows peculiar markings and pinholes. I think it would be desirable for those who are investigating the subject to make a test of that sort if it takes three months to a year to get results. The whole subject is getting down to a question of how much it will cost to put on a chromium-plate that will last as long as an automobile is expected to last.

There are some peculiarities about putting a chromium-plate under a coat of brass, with chromium on top of the brass. This is a field of investigation which has been absolutely neglected, so far as I could find out. Certain indications lead some to think that a plating of brass rather than of copper may be the solution of the problem of corrosion.

It has been my experience that, if too much chromium is put on, the chromium peels and takes all the nickel, and sometimes the copper, with it. The plating sometimes rises in little blisters on the skin that can be seen under a magnifying glass. Has Mr. Baker noticed that in the heavily plated chromium jobs?

ADHERENT PLATING REQUIRES CLEAN BASE STEEL

PROFESSOR BAKER:—In these cases there was no raising of the base plate by the chromium-plating. I believe many people have experienced that difficulty in commercial plating, but if the base steel is properly cleaned, so that it is free from surface oxidation, and if the plating is done under proper conditions, there should not be any great difficulty in getting adherent plate. If the base plate is adherent, the chromium will not raise it. If it is not adherent, I do not know of any more

[1] The paper was printed in the March, 1928, issue of THE JOURNAL, p. 331, and the abstract of the paper is reprinted herewith to make obvious the references in the discussion to various points and is supplemented by a synopsis of the principal trend of the discussion. Of the co-authors, Edwin M. Baker is assistant professor of chemical engineering at the University of Michigan, Ann Arbor, Mich.; and Walter L. Pinner is connected with the C. G. Spring & Bumper Co., Detroit.

[2] M.S.A.E.—Consulting metallurgical and industrial engineer, Evanston, Ill.

effective way of taking it off than by applying a fairly heavy deposit of chromium.

A correlation of weather tests with salt-spray tests would certainly be of value. As you have indicated, weather tests are slow at best. Some investigators favor them and others do not. One difficulty is that only approximate results can be obtained, as there is no such thing as a standard weather-test. To secure comparative results it is necessary to use some method of testing that is approximately reproducible, even though it may not completely duplicate service conditions.

QUESTION:—How long will nickel or chromium-plating stand?

MR. PINNER:—Chromium-plating on test pieces which withstand the salt-spray test for an average of 50 hr. will last more than a year in service. I have some chromium-plating which has been in service on my car for a year, and which is still bright and unrusted. Other pieces from the same batch stood up under the salt spray about 50 hr.

CHROMIUM-PLATING ON TOOLS AND GAGES

CHAIRMAN A. R. FORS[3]:—Can anyone give us some information on what he is doing with chromium-plating on tools and plug-gages, and what the tests show?

ORLAN W. BOSTON[4]:—We tried to plate two pieces of steel that were ground, after being hardened, to the Seller standard shape No. 30, that is, for cutting hard steel. One was carbon steel and the other high-speed steel. They were chromium-plated. I am not sure of the quality of the plating, as I did not do it. The first test that we used them on resulted in the chromium leaving the tools, but we hope to continue that test.

W. N. PHILLIPS[5]:—We are getting about five times the life from a chromium-plated plug-gage as from an unplated steel gage. The length of life varies with the number of threads for which the gage is made and all such things.

We do not find that chromium is very suitable for cutting tools that have to stand high pressures, although it is sometimes satisfactory on cutting edges that operate at low pressure. We get very good results with it on nearly all burnishing tools.

CHAIRMAN FORS:—On plug-gages, do you find there is any advantage whether the hole that is gaged is reamed, ground or honed? I have heard some mention of using chromium-plated gages for reamed holes, which did not stand up much better than a steel gage.

MR. PHILLIPS:—We have not had any particular difficulty on that score. The wear naturally will depend on the material that is being tested. As the hardness of the material approaches that of the chromium, you would not expect the gage to wear so long.

SUCCESSFUL ON LIGHT-LOAD BEARINGS

CHAIRMAN FORS:—Can you tell us something about chromium-plated running bearings?

MR. PHILLIPS:—We are chromium-plating on some bearing surfaces with considerable success. There, again, some care must be taken about pressures. Chromium-plating cannot be substituted universally for carburizing, by any manner of means. If the metal is soft and the pressures high, it is useless to put on a thin film of chromium and expect to get good results, but it can be used where the pressure, measured per square inch or otherwise, is light.

CHAIRMAN FORS:—Has any more been done on chromium-plating piston-pins than was mentioned in your paper[6] presented at the 1927 Annual Meeting?

MR. PHILLIPS:—Yes, we are plating 25,000 a day now, I believe.

E. F. WILLETT[7]:—At our plant in Jackson we chromium-plate about 1500 fanshafts per day. The journals run in cast-iron bearings. This fanshaft is not hardened; it is ground to good shape and then chromium-plated, and it is giving much better service than the hardened shafts have given.

We also have conducted a number of tests on combination water-pump and fan shafts, and find that the chromium-plated shaft stands up very well under the packing. We have put out probably between 550,000 and 600,000 fans with the chromium-plated shaft, and do not have trouble with them, although we have found that, under extremely heavy V-belt pulls, the shafts do not always stand up.

[3] M.S.A.E.—Production engineer, Continental Engine Corporation, Detroit.

[4] Professor of shop practice, director of shops, University of Michigan, Ann Arbor, Mich.

[5] Factory production engineering section, General Motors Corporation, Detroit.

[6] See THE JOURNAL, February, 1927, p. 255.

[7] A.S.A.E.—Treasurer and sales manager, Automotive Fan & Bearing Co., Detroit.

Paved Highways Save Tires

NO less than $1,918 yearly may be saved on tires for each mile of high-type pavement that replaces gravel or macadam roads, according to the last service bulletin of the Iowa Highway Commission, which takes as a basis the recent investigations of Washington State College. This means that, where automobile traffic is heavy, the saving in the tire wear alone justifies paving.

The amount of rubber worn off during the life of the tire is about 3.45 lb. It was found that, on a good crushed-stone macadam surface with 500 vehicles traveling over it daily, the tire-wear cost in the course of a year is $2,590 per mile. The cost on rigid pavements with the same number of vehicles is only $672.

The Washington State College has found that a properly constructed concrete pavement may be expected to give service for at least 25 years. Spreading the entire cost of the pavement over this period, the average cost per year is $1,840. This figure is actually $78 per year less than the saving in tire wear effected through driving on the rigid pavement.—*Motor Travel.*

Design and Operation of Modern Garages

By GLENN S. WHITHAM[1]

NEW ENGLAND SECTION PAPER — *Illustrated with* DRAWINGS

THE design of the modern multi-story urban garage, commonly built of reinforced concrete, is based largely on arrangements for the vertical movement of individual cars at higher speed than prevailed in the garages of the older types, or the vertical movement of a greater number of cars at the same speed, according to the author. Basic considerations affecting the design are location, type of district, capacity, and method of vertical movement. Location on a main thoroughfare is advocated. The location in several typical districts, such as retail-shopping, office-building, hotel and club, theater and amusement, and middle or high-class residential, are discussed in connection with the several classes of patronage and their bearing on design and equipment.

Proper size is best determined by a careful survey of the available garage-business load, giving full weight to such factors as trend in change of character of the district, proposed widening of or changes in adjacent streets, proposed new buildings that will furnish garage revenue, existing garage facilities, possibility of erection or enlargement of other garages, and likelihood of changes in traffic regulations. Other factors to be considered are the height to which car owners will be willing to drive up ramps, traffic capacity of the street or streets feeding the garage, and number and separation of car entrances and exits. Thought should be given also to the possibility of enlarging the garage laterally or vertically. Shape of the plot and its boundary by at least two streets, each having a width of not less than 45 ft. between curbs, are important. Two general methods of vertical movement of cars are analyzed, one by elevators and the other by ramps.

Development of ramps has been a prominent feature in the last 10 years. Types of interior and exterior circular ramps and two-way-traffic straight ramps, and the d'Humy type of garage construction having floor levels on one side intermediate with the opposite floor levels, with connecting ramps of small gradient, are described.

Three important considerations when laying-out a garage design are the saving of time of customer and garage operator, comfort of customer and operator, and prevention of dissatisfaction of either. Each of these layout factors is analyzed. Structural materials, fire protection, heating, lighting, water supply, drainage, door types and locations, and other details are analyzed also, as well as conditions influencing gasoline storage and the filling of car tanks, and the location of the repair-shop, the tire service, the accessory department and the office and waiting-room. Details of equipment for gasoline, oil, washing, merchandising, tire repairing, battery service, greasing service, and emergency service are stated. Personnel problems and other garage-operating problems are also treated.

The discussion of the paper deals in the main with ventilation and the use of ozone-gas machines to obviate danger from monoxide gas, the harmful effect on brake-linings of the use of soap-and-kerosene mixtures for washing automobiles, leakage of oil from pressure oil-dispensing outfits having flexible metal-hose, and how to keep an accurate check on the quantities of oil dispensed. A liquid gage for checking the contents of storage tanks is described, and types of ramp are illustrated and explained in considerable detail.

IT seems strange that the garage industry, of practically the same age and working hand in hand with the rest of the automotive industry, has escaped technical attention so long. Only a comparatively small amount of concerted study and consideration has been devoted to garage problems, and the attention they have received has been largely of a local character. For example, we have in the vicinity of Boston the Metropolitan Garage Association, which is now functioning in its fourth year. The International Garage Association, covering the eastern part of the United States and Canada, is not yet a year old. And I believe that this is the first meeting of the Society which has been devoted entirely to a discussion of garage problems.

The scant attention so far given the garage industry is all the more surprising when the extent of garage investments is considered. An idea of their magnitude is conveyed by the fact that the "In-Town" territory in Boston, bounded by the Charles River, Massachusetts Avenue, South Channel and Boston Harbor, alone comprises garage investments which total almost $20,000,000. The capital investment in modern garages in the entire United States is approximately $2,000,000,000, an amount somewhat greater than our National debt just prior to the World War. This investment grows and the necessity for devoting the best thought to garage planning is therefore apparent.

The following figures for the year 1926, the last year for which the data are available, obtained from David Beecroft of the Chilton Class Journal Co., indicate the increasing ratio of service to new-car sales. The retail value of passenger-cars and trucks sold in the United States and Canada was approximately $3,800,000,000. Less than 14 per cent of this amount represents the retail value of trucks sold, and less than 5 per cent applies to sales made in Canada. The 1926 bill paid by the motoring public of the United States and Canada for operation and maintenance was $4,815,000,000. This

[1] M.S.A.E.—General manager, director, Charles Street Garage Co., Boston.

is 26½ per cent greater than the retail value of the new vehicles. Divided equally among the registered cars, it shows that an average expense of $200 per year per motor-vehicle was incurred for operation and maintenance.

History of Garage Development

The first garages, particularly in the smaller communities, were converted livery stables; the first repair-shops were the blacksmith shops. This is the trend which might have been expected and shows definitely the tremendous evolution of our transportation facilities during the last 25 years. This evolution is apparent, even today, when the fire underwriters' rating bureaus classify under the same heading "Livery Stables and Garages." When the two are compared today, the fallacy and injustice of this classification is evident.

The term "modern garage" means a building of fireproof construction adaptable for the rapid receiving, complete care and easy egress of automobiles. Most of its development has been in the post-war period. The distinction of the modern multi-story garage lies largely in arrangements for the vertical movement of individual cars at higher speed than prevailed in the garages of the older types, or the vertical movement of a greater number of cars at the same speed. The cost of land in the more highly developed urban centers almost precludes the use of single-story garages. It is particularly in respect of more highly developed vertical movement that the modernizing of garages and their increasing use by the motoring public has been brought about. My discussion of the subject is based on an urban passenger-car garage. Many of its patrons are transients. The building not only has space for the parking of cars but is equipped with facilities for giving them the attention that is necessary for their successful operation and for catering to the desires of their owners.

Basic Factors of Design

The four factors I shall analyze are location, type of load, size or capacity, and method of vertical car-movement.

The logical location for a garage is upon or near a main artery of travel used extensively by the class of persons to which it is expected to cater. Survival of the idea of livery-stable practice accounts, no doubt, for some people believing that garages should be located on side streets, back streets, or alleys. A distinct prejudice against any other location has frequently been noted, but, with the widening and better surfacing of city streets, better traffic-control, and the transition of public transportation from street-cars to motorcoaches, the main-artery location became popular for the modern garage. Such locations are just as essential for successful garages to serve the demands of the public properly as for hotels.

The advantages of a main-artery location seem, from experience, greatly to outweigh the more obscure locations. One outstanding advantage is the self-advertising value. Large numbers of cars pass such a location every day and properly devised signs convey to the motorist a much more lasting impression of the garage than he will obtain through any other medium of advertising. Car drivers in need of emergency service will be much more likely to patronize a garage so located than one on a back street. The practice of naming a garage by its street or district location has been fairly common, and if the street is not too long or the district too large or vague, this has a definite value, especially if the street or district be prominent.

Main arteries of travel usually are fairly wide, which makes it easy for patrons to reach the garage and to avoid temporary congestions in narrower streets. Cars leaving a garage located on a main artery are quickly in the stream of travel and their drivers have the feeling that they are not wasting time in getting away. Another important advantage of the main-artery location is that it is usually much easier and, with its wider sidewalks, more pleasant to reach on foot than is a more obscure location. This advantage is especially marked at night, when the main arteries are more adequately lighted. Many of the same reasons that prompt retail stores to seek a location along a street of heavy pedestrian-traffic prompt the prospective garage builder to locate on a street of heavy motor-traffic.

One disadvantage of locations on some main arteries is that traffic may become congested at times so that access to and egress from the garage may be somewhat impeded. As a rule, however, a proper arrangement of entrances and proper methods of handling cars inside the garage will offset this. From an economic consideration another disadvantage is that land in such a location is usually of considerably higher value than in a more obscure location, and there is a very definite limit to the price of land for each particular city and location beyond which, from the viewpoint of profitable operation, it is not advisable to go when purchasing land for garage development.

Character of District Served

Another important point is to choose, if possible, a site near the inbound terminus of an important automobile artery. This, as a rule, results in a location near some important retail shopping-district, office-building district, hotel-and-club district, theater or amusement district, or a middle or high-class residential district. These five types of district are the most fruitful sources of income.

When a location can be selected from which more than one of the foregoing types of district can be served, the location is of distinctly greater value. One of the best locations of which I know serves four of these types, and it therefore has a good load for practically 24 hr. every day. Shopping and office-building districts are productive of garage business for only a portion of every week-day, there being often a short business day on Saturday and almost no business on Sunday. The business from hotels and clubs and from theaters is spread over a greater part of the day but, as a rule, it is not of enough volume to keep a garage sufficiently filled to yield a proper income.

A residential district of the better class may be productive of a more satisfactory load, because cars usually are handled on a 24-hr.-per-day monthly storage-basis. It will thus be evident that a combination of as many as possible of these districts in proximity to a garage will result in a much better distributed load. It is desirable also, if possible, to secure a central location in the load area. A location to one side of the area to be served means that the load at the farthest point from the garage is usually at such a distance as to make it difficult to attract customers.

The shopping-district load, which consists to a considerable extent of women drivers, has different re-

quirements than most of the other types. It is very desirable to have entrance to the garage made easy. This can be done by paying close attention to providing a proper grade at the entrances, making the entrances wide, marking them properly and plainly, and by providing, if possible, a right-hand turn into the garage from the usual course of travel so that other lanes of traffic need not be crossed.

Inside the garage there must be a clear and unobstructed driveway to the point of checking, and easy turns and grades to the place where the customer leaves the car. An adequate waiting-room must be provided with rest-room facilities and provision for checking parcels with the minimum effort. It is desirable also to provide adequate facilities for the sale of gasoline and oil. Tire-repairing and lubricating equipment, complete car-washing facilities, and uniformed-chauffeur service are real necessities. The arrangement of the garage should be such that cars can be removed in the shortest possible time and with the least effort and confusion.

A main requirement for caring adequately for an office-building load is the provision of ample entrance facilities to expedite the handling of cars from the street to the point at which the customer leaves the car. It is essential to afford easy and safe egress for customers who leave on foot; this also applies to shopping-district conditions. It is desirable to have an office and lobby located near that part of the building at which the majority of customers will arrive first when coming from their offices. This will give them the feeling that no useless steps are expended.

For an office-building load it is desirable to have adequate facilities for gasoline and oil service, tire repairing, lubrication and washing. Every effort must be made to provide rapid egress for cars, as this is one of the advantages most sought after by business people, who usually are in a hurry to get home or out of town at the close of the business day.

The hotel and club load-requirements differ somewhat from those already mentioned. First in importance is the convenience of location of the garage for a stranger. Then comes the necessity of accessible and plainly marked entrances with, if possible, a right-hand turn from the ordinary course of traffic. Facilities must be provided for supplying gasoline and oil, for tire repairing, for lubricating, and for high-grade washing, which includes thorough cleaning of the inside of cars. This is probably one of the most particular classes of trade with which the garage is required to deal. Facilities for at least minor mechanical adjustments must be available.

The theater-and-amusement custom demands a combination of the requirements of the shopping load and the office-district load. Provision must be made for the convenient and easy handling of cars driven by women, and special attention must be paid to facilities for rapid handling while cars are being checked in and checked out. The theater load, especially, is a peak load and serious congestion may result at points such as cashiers' cages, elevators and exits, unless adequate facilities are provided. Such congestions will invariably result in forcing customers to other garages wherever they may be available.

A residential-district load has certain requirements which differ somewhat from any already discussed. Important among these are:

(1) Adequate space inside the garage entrance for cars to be left before they are placed in their permanent stalls by the attendants

(2) Ample and easy checking facilities for a long list of items such as tires, chains, robes, luggage-carriers, trunks and radiator shutters

(3) Office facilities arranged for the quick handling of customers' cars. Customers who acquire the habit of using the telephone in conveying their orders to the garage usually comprise the most profitable class. It is imperative to make a vivid impression that it is a very simple matter for the customer to have the garage render any kind of service. The efficient layout of the office, with this in mind, will be well rewarded

(4) Provision must be made for more service than for the other types of load, such as additional facilities for complete mechanical repairs, towing and emergency road-service, chauffeur and delivery service, special cleaning and body polishing

Garage Size and Capacity

The maximum capacity of a proposed garage, from a purely physical standpoint, is governed somewhat by the ground area available and by the local building restrictions as to height. It is never certain that a garage should be built to its maximum possible capacity until many other factors of great importance bearing upon this point have been carefully considered. The proper size is best determined by a careful survey of the available load, weighing fully such factors as the following:

(1) The trend of change in the character of the district to be served, as it affects the use of cars

(2) Any proposed widenings or radical changes in the streets adjacent to or near the garage site

(3) Any proposed new buildings which will furnish garage revenue

(4) Existing garage facilities, as to both amount and quality. This is one point that is often overlooked. It has been the history of the business that in nearly every case the garage has come before the load was created to fill it properly. While this makes for comfort of the automobile owner, it causes the garage to pass through a period of small earnings or even losses before it can be said to be on a sound business basis. Drivers who have been going for years to one garage do not change suddenly to another, and certain attachments and friendships are formed which it is not easy to break up

(5) The possibility of increased garage facilities in the neighborhood, either by the erection of new garages or the increase in size of existing plants by competitive interests, should not be overlooked

(6) Changes by municipal authorities in parking regulations or in other enforcements that sometimes create an apparent sudden demand for garage space. The history of these cases is that, as a rule, the heavy parking-demand is only transitory and that the energy of enforcement will wane after a few months. On the other hand, a continuous trend exists in this respect which is making for increased need of parking facilities other than along the curbs of public streets in single and often double lines. Streets should be regarded as means for handling traffic expeditiously and safely; not as parking spaces

(7) When making a study to determine proper size, the distance of the project from the center of

the load is an important consideration. It is becoming increasingly noticeable that motorists do not like to walk. As a rule, the nearer to the center of its load a garage can be built, the more certain it is to be well patronized

(8) The height to which customers able to handle their own cars will be willing to drive is a further consideration. This refers to the ramp type of garage which is becoming increasingly popular and probably will continue to do so. Already several garages are in operation which are fully 10 stories high, and at least one, I understand, is planned for 12 stories. A serious question exists whether a height limit will not be reached, or perhaps has been reached, beyond which it will be inadvisable to build. Seemingly the car owner is affected, not only by the time factor or the distance factor, but also by the apparent complication and difficulty of handling cars to a considerable height. In those garages in which cars are handled above the first-floor level by the garage employes, the height limit will be determined more or less by the time element and the arrangements made for the transportation both up and down of the employes when they are not driving cars

(9) The traffic capacity of the street or streets feeding the garage is another factor which limits garage capacity. If a garage extends between two streets of considerable width, it can certainly care for many more cars than if it were dependent on one street only. If these streets are narrow, a definite limitation is put upon the size of the garage

(10) The proximity and size of competitive garages is a very important factor

(11) The number and separation of car exits and entrances have a direct bearing upon the advisable capacity

Another line of study in giving consideration to garage capacity involves a general question of good business, depending upon the interrelation of capitalization required and probable returns. There should be reasonable assurance of patronage for a considerable part of each 24-hr. day. The higher the capitalization is and the lower the rates are, the greater is the portion of the day that should be covered. For this reason, residential business is especially desirable, since it involves storage on a 24-hr. basis. The monthly storage of cars for the day period generally is negotiated on a basis considerably lower than the 24-hr. basis. If there is not a good flow of cars into the garage during the evening and night, the total income may easily be inadequate even though a day business of considerable size is handled.

Another item for consideration in garage planning is the possibility of enlarging the plant when the load increases. This enlargement may be either lateral or vertical. If it is felt that an enlargement is bound to be necessary within a reasonable time, the enlargement may just as well be vertical; whereas, if some element of doubt exists as to whether an enlargement will be necessary, it would be better to plan to enlarge in a lateral direction. The reason is that, in case the enlargement should be found unnecessary, the garage does not cover the entire area of the land which the ultimate plan involved and the land or adjoining property is available for other uses which will not impair the value of the original garage as built.

One point upon which there is a considerable difference of opinion is the existence of a definite maximum capacity for any given location. Some who have given this matter careful study hold that this maximum capacity varies from 250 to 650 cars. This may be seriously questioned by others, who firmly believe in immense plants, but it is my opinion that it has not yet been definitely demonstrated that it is desirable to build beyond a capacity of 650 cars in any one unit. A better alternative than a garage of very large size is the building of two or more smaller units.

The size and shape of the plot available for use for garage development has a direct bearing on the garage

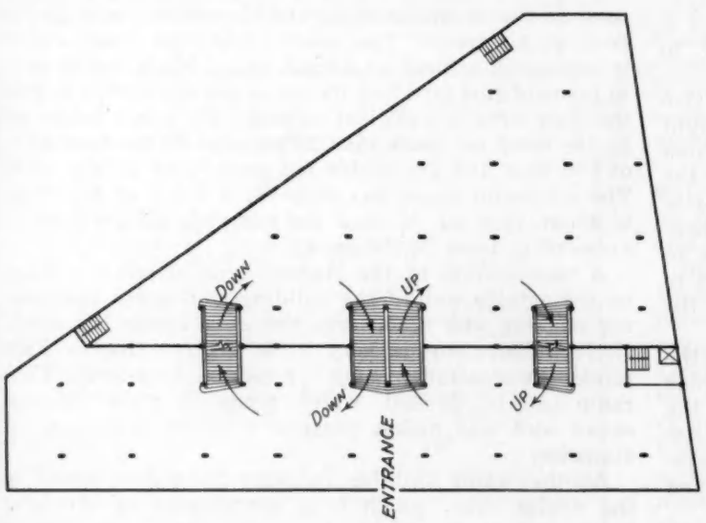


FIG. 1

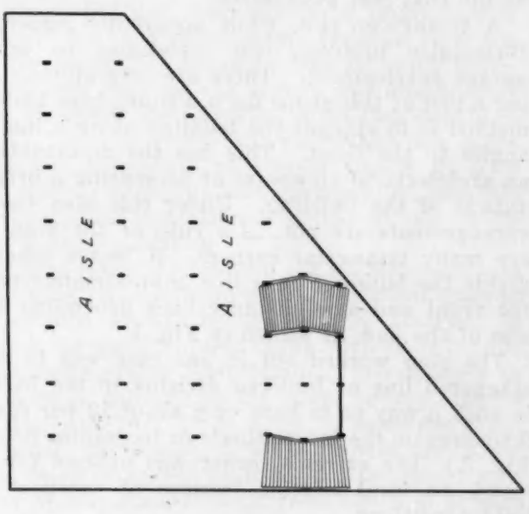


FIG. 2

UTILIZATION OF A TRIANGULAR GARAGE-SITE

The Methods Illustrated Apply to the d'Humy Type of Ramp. The Method Shown in Fig. 1 Is To Divide the Building on a Line Approximately Parallel to the Front and at a Distance Toward the Rear Depending upon the Size of the Plot. In Fig. 2, the Staggered Line of Building Division in the Back Corner Was Made in Such a Way as To Have Only about 12 Per Cent of the Floor Area on the Intermediate or Mezzanine Floors. The Extreme Corner Was Used for a Wash-Stand.

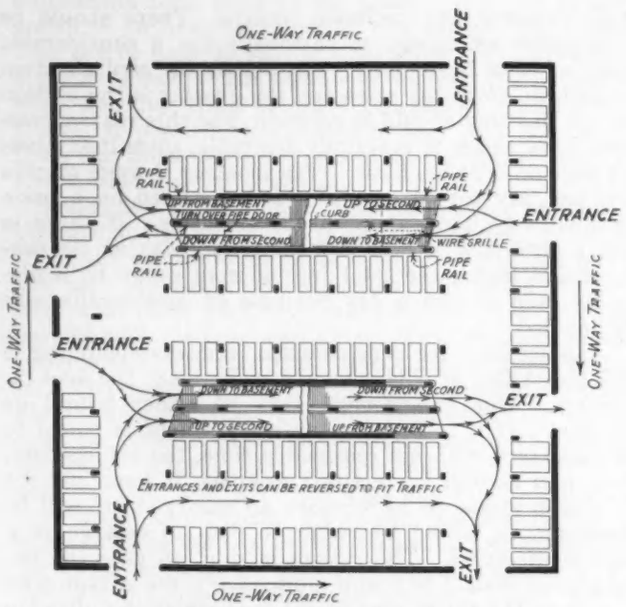


FIG. 3—JOSLIN DUPLEX TYPE OF RAMP

This Type Is Suitable for Very Large Floor-Areas. It Is a Combination of Straight Ramps That Permits Two Lines of Traffic Both Up and Down Simultaneously Without Interference

design. The ideal plot is bounded on at least two sides by streets of fair width, at least 45 ft. between curbs. It should have right-angle corners on account of the difficulty of economical spacing of columns to provide the maximum car-capacity in a garage built on an irregular plot. Oblique corners provide one of the greatest difficulties with which the designer has to cope in making the layout for the maximum capacity in cars so that they can be safely and easily handled. A minimum of 10,000 sq. ft. of land should be available for the building, and the rectangular plot should have one dimension preferably of 100 ft., but with 60 or 65 ft. as the next best alternative.

A triangular plot, while apparently somewhat of a formidable problem, can sometimes be adapted to garage development. There are several ways of utilizing a plot of this shape for a d'Humy-type garage. One method is to stagger the building along a line at right angles to the front. This has the disadvantage from an architectural viewpoint of presenting a break in the façadé of the building. Under this plan the interior arrangements are not, as a rule, of the best, as there are many triangular corners. A better scheme is to divide the building on a line approximately parallel to the front and at a distance back depending upon the size of the plot, as shown in Fig. 1.

The plan worked out in one case was to make the staggered line of building division in the back corner in such a way as to have only about 12 per cent of the floor area on the intermediate or mezzanine floors. (See Fig. 2.) The extreme corner was utilized for a washstand, an ideal location because of excellent air and light conditions.

METHODS OF VERTICAL CAR-MOVEMENT

The various ways of getting cars from street level to upper floors can be divided into two general classes: elevators and ramps. Elevators are especially adaptable in cases in which the single-floor area is rather small and which, if a ramp were used, would be reduced materially by the necessary driveways incidental to the use of ramps. Elevators also form a satisfactory means of vertical movement where peak loads do not exist regularly. Where a garage caters to a hotel-and-club or to a residential-district load only, they have proved especially satisfactory.

Elevators are no longer slow and dangerous. High-speed elevators of the push-button type which can be operated by inexperienced help are available, and they operate at speeds of 200 ft. per min. and more. One Chicago garage in a large office building utilizes elevators designed to operate at a speed of 600 ft. per min. if necessary; they serve 23 floors, each floor having a capacity of about 25 cars.

The micro-leveling feature, whereby absolutely accurate leveling of the elevator floor with the floor at which it stops is maintained, saves time and is especially desirable. This promotes ease in driving a car on and off the elevator and reduces the strains on the elevator rails. During the period of driving off, as the elevator load is reduced and the stretch of the cables is taken up, the elevator is automatically lowered sufficiently to keep the elevator floor even with the garage floor under all conditions. All the modern elevator installations have safety doors which make it impossible for a car to fall from any floor into the shaft, because the doors can be opened only when the elevator is at that particular floor level.

USE OF RAMPS TO MOVE CARS VERTICALLY

The development of ramps during the last ten years has been one of the outstanding features of the garage-building industry. The early type of so-called straight ramp from floor to floor may be an outgrowth of those formerly used in stables for leading horses to upper floors, but the newer types apparently have no prototypes. The so-called Harvey type consists of two circular concentric sloping driveways which, as usually operated, are both traversed in a counter-clockwise direction. The outer circle, having a lesser grade, is used as the up-going ramp and the inner circle as the down-going ramp. The space inside the inner circle is ordinarily utilized as a light well. Much can be said in favor of this type, but its use is not economical unless the floor area is sufficient to make the space taken up by the ramp not more than 25 per cent of the total area of the floor and preferably not more than 20 per cent. The minimum space necessary for a ramp of this type is about 7500 sq. ft., and the ramp should serve floor areas of at least 30,000 sq. ft.

A modification of the Harvey type places the ramp on the outside wall of the building and makes available for parking and other uses the area inside the ramp circle. The ramp is very little greater than a half circle, the remainder being the regular floor-level. This ramp can be banked, which tends to make driving easier and also makes possible a slight reduction of diameter.

Another ramp suitable for very large floor areas is the duplex type, which is a combination of straight ramps developed by L. S. Joslin and used in the Motor Mart Garage in Boston. This type, shown in Fig. 3, enables two lines of traffic to go up and two to come down simultaneously without interference because the cars in adjacent lines always travel in the same direction and there is no crossing of traffic.

By far the most significant development in garage ramps is the d'Humy type. This involves the dividing of the building into two series of levels separated by a vertical wall, one series being vertically a distance of a half story from the other. Thus, connection is made possible between successive floors by ramps of only half the rise necessary if the floors are not staggered. A car progresses from the lower to the upper levels by traveling alternately from one series to the other on these short ramps, all the while following a generally circular path.

Of the several types, the simplest is the single ramp shown in Fig. 4, which provides for only one car at a time to pass between adjacent floors. A car cannot go up from the first to the second level while a car is coming down from the second level to the first. This type is practicable only in garages of moderately small capacity. If the ramp is supplemented by an elevator, the capacity of a garage using this type can be increased greatly, because advantage can be taken of routing only the predominant traffic on the ramp at one time. Hence, when a majority of the cars are coming into the garage the ramp would be used for "up" traffic only, and vice versa.

The double type has a roadway sufficiently wide for two cars to pass easily. By routing the up-going traffic counter-clockwise and the down-going traffic clockwise, and enforcing the rule to keep to the right, this ramp is very satisfactory. In the divided concentric type, shown in Fig. 5, both ramps are of single width, and it is possible for a line of cars to be passing up at the same time that cars are passing down. In this way both lines move in the same circular direction; that is, both are moving either in a counter-clockwise or in a clockwise direction. An undivided type of concentric ramp is also available.

The tandem ramp, which is more adaptable in a long-shaped building, consists of two single ramps somewhat separated so that the two lines of traffic do not interfere, one ramp being used for up-going and the other for down-going traffic at all times, as indicated in Fig. 6. Each of the foregoing types has its place, which is determined by the shape and size of the plot, the capacity of the garage, and the layout of aisles.

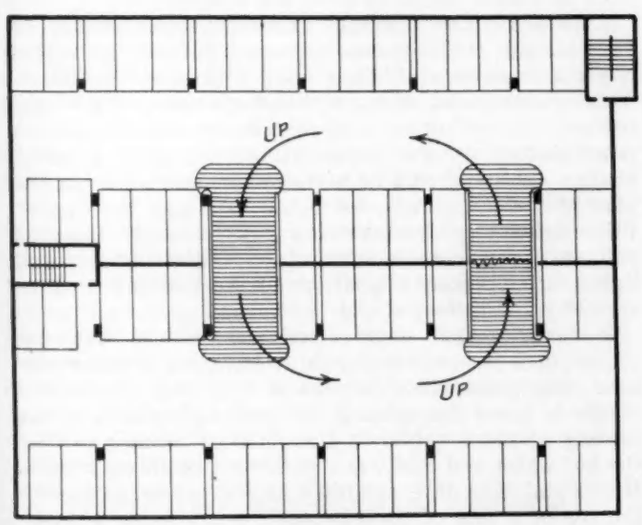


FIG. 4—SINGLE TYPE OF D'HUMY RAMP

Only One Car at a Time Can Pass Between Adjacent Floors. This Type Is Practicable only in Garages of Moderately Small Capacity

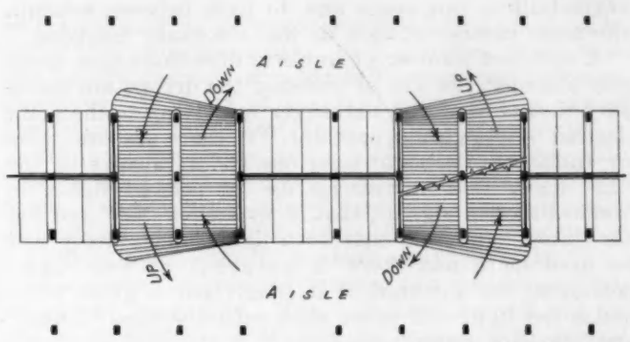


FIG. 5—DOUBLE CONCENTRIC D'HUMY RAMP WITH DIVISION WALLS

Both Ramps Are of Single Width and It Is Possible for a Line of Cars To Be Passing Up at the Same Time that Cars Are Passing Down. In This Way Both Lines Move in the Same Circular Direction; That Is, Both Are Moving Either in a Counter-Clockwise or in a Clockwise Direction

PRIME CONSIDERATIONS OF DESIGN

If three important points are kept in mind when laying out a garage design, it is most likely that the best possible garage will be evolved. The points are: the minimizing of time consumed by both the garage customer and the garage operator, the increasing of their comfort, and the prevention of their dissatisfaction.

First, in minimizing time for all concerned, it is essential to provide garage entrances of ample width. The facilities for the checking-in of cars should be provided for at a sufficient distance from the entrances so that a considerable number of cars can enter in rapid succession without creating congestion at the entrances. If the ramp-approaches to the upper floor are set well back from the entrances, this will provide a clear working-space inside for the handling of several cars. If the design of the building is such that it is impracticable to place the ramps at a considerable distance from the entrance, the checking-in should be done on upper floors. In such case cars entering the garage will immediately ascend the ramp without stopping until they reach an upper level. The day when city authorities will cease to tolerate the congestion of streets caused by cars waiting to enter a garage is fast approaching, and this phase of design and operation is bound to receive increasingly greater attention.

Another time-saver is provision for backing cars into their stalls with the minimum effort. Sufficient spacing between columns should be allowed, if possible, to enable cars to be backed in one swing without being too careful to avoid striking the columns. The distance in the clear between columns should never be less than 20 ft. for a three-car bay; 21 or 22 ft. is more desirable. Columns should be located so as to provide for wider aisles. In most cases the columns can be placed at a distance of approximately 12 ft. from the wall or stop that is at the rear of the line of cars.

Although the tread of most automobiles has not changed, the advent of balloon tires has necessitated the widening of fenders. Some of the 1927 cars have overall widths several inches greater than 6 ft. If this trend continues it will be difficult, in some of the ga-

rages built a few years ago, to park between columns the same number of cars as was originally intended.

A sufficient number of uniform direction-signs, properly placed in the line of vision of the driver, are necessary to save time for a stranger in driving to the point desired by the garage operator. If there are two doors or entrances, the right-hand one should always be the "In" door. The increasing use of colored lights in traffic-direction signals, that is, green for "Go" and red for "Stop," suggests that such lights undoubtedly will be used more and more in garages. At two ramp-entrances, for instance, it is likely that a green light and a red light will prove more effective than "Enter" and "Do Not Enter" signs.

Design Factors That Increase Comfort

In the planning of a garage, provision should be made for as many outside windows as possible. Natural light will effect a considerable saving in electric current for lighting, and will render much more attractive and hospitable all the floor area near these windows. The architectural appearance should be a secondary consideration, and under almost no conditions should windows be omitted for the sake of maintaining certain building lines that may be attractive to the eye from the outside but do not produce revenue.

The operating-office location should be near to where the customer leaves and enters the garage on foot. Passenger elevators should be near the office, and so should the waiting-rooms and the checking facilities. There should be a central headquarters for the contact men with whom the customer deals in making arrangements for anything pertaining to his car, and for registering complaints.

Prevention of Dissatisfaction

Column guards wide enough to keep fenders of cars away from the bases of columns are valuable. They should be of suitable height, but not so as to come into contact with running-boards and running-board supports. A good height is 8 in., with an extension of 4 in. toward the parking space but no projection on the aisle side of the column. Such guards will reduce the number of cases of scraped fenders. It is a moot question whether concrete guides of any sort are desirable to assure the parking of cars in their proper stalls. The one type of guide which seems to be in greatest favor is the type placed under the car between the wheels. This should be pointed at the forward end to allow the car to make the right-angle turn into the aisle, preferably without backing. The advantage of placing the guides between the wheels rather than between cars is that there is less danger that persons entering the cars will trip over them.

All obstructions with which they might collide should be kept away from the sides and rear ends of cars. This refers especially to radiators for heating. Heating units located close to the ceiling, and electric-driven fans for circulating the hot air, have become popular. Garages having radiators extending around the lower part of the walls experience a great deal of breakage from cars backing into them unless proper car-stops are provided. Water pipes, drains and other such necessary installations should be located carefully to avoid all chance of their being disturbed by cars. These are effective methods of preventing dissatisfaction of the operators and damage to the cars.

Specific Problems of Design

Structural Material.—Reinforced concrete is by far the material used most in garage construction. In garages of great height the lower columns are often built of structural steel incased with concrete so as to reduce their size. Different types of floor slab have been used, but it is doubtful if anything more satisfactory than the flat slab has been devised, with beam and girder design when span length requires it. The flat slab has less surface to paint and also has better light-reflecting qualities. If the floors are carefully poured and proper attention is given to the joints, there need be very little cracking of the floor slab later. This has been a source of considerable trouble to almost all garage operators. Water leaking down on cars from upper floors carries a certain amount of fine material from the concrete slab above, sometimes of a chemical nature which is injurious to the finish of cars, particularly to varnish. The prevention of cracks in concrete floors is a subject worthy of study.

Fire Protection.—The use of sprinkler systems in garages is compulsory in many cities. In any case, there is a considerable reduction in the insurance rate if a sprinkler system is installed. If large areas are likely to become more or less exposed to cold because of the necessity of keeping doors opened, a dry system is preferable to filling the exposed pipes with anti-freeze solution, but this can be done where only small areas are involved.

Heating System.—Heating by steam is almost universal. In a large plant the use of coal rather than oil probably has the advantage; but, in smaller plants located where the winters are not severe, oil heating has the advantage of making steam at short notice and at times when it is needed. Somewhat less supervision is required for oil-burning equipment, but the supervision must be of a higher grade. If coal is used, it is distinctly advantageous to have ample coal storage so that coal can be bought in carload lots. Heating units are much better than radiators or pipe coils for garage use, as the building can be heated very quickly by means of the units. In many cases they need be run only an hour at a time, two or three times a day.

Lighting.—The lighting fixtures proper should be very simple. In most cases where a flat ceiling is used a plain receptacle at the ceiling will prove sufficient. This arrangement, using a receptacle without a shade, utilizes the ceiling as a large reflector and provides a much better general illumination than does a metal shade. Lights should be arranged so that those in the part of a floor that is not being used can be cut out. Pilot lights placed where they can be easily observed will save considerable current by indicating burning lights in unfrequented portions of the building, such as stairways, storerooms and basements.

Water Supply.—Aside from wash-stands and fire stand-pipes, it is not desirable to have many water outlets. One point often overlooked in piping, where provision is made for mixing hot and cold water, is the placing of check-valves at the point of mixing so that the hot water and cold water will not mix unless needed. Horizontal runs of water pipes should not be made over the top of a line of cars, because, under certain conditions, cold-water pipes sweat and water will drip on the cars. Hot-water pipes, as well as steam pipes, should be covered with insulation.

Drainage Facilities.—Floor drains should be located so that at least one is available for each 2000 sq. ft. of floor area. These should be preferably at the back of the lines of cars, so that the aisles can be kept dry and any horizontal drainage pipes can be kept away from the point above the space on the floor below used for parking cars, where the pipes might either interfere with cars or necessitate a greater ceiling-height. The pitching of floors into the drains located as recommended is very important but is generally disregarded in construction if not in planning.

Floor Finish.—Floors should be finished smooth. The idea of having them rough to provide traction is, in my opinion, fallacious. It is much easier to keep a smooth floor clean, and much less dust accumulates on a smooth finish than on a rough finish. This is especially noticeable in new garages before the floor has become partly saturated with oil.

A smooth floor treated with a good hardener will accumulate very little dust. The use of steel dust instead of sand in the finish coat is recommended by some experienced garage builders. Some abrasive should be worked into the top coating of wet concrete at turns, especially at the tops and bottoms of ramps. In the finishing of the ramp surface it is desirable to rib it by using concrete-finishing tools. If this ribbing be set at an angle of about 45 deg. it will be effective in keeping the ramp surface free of water. Some builders, who use abrasive such as carborundum or alundum in the ramp surfaces, claim to get better traction and much less wear that is due principally to tire chains.

Ramp Features and Story Heights

In laying out a ramp it is desirable to place a curb at least 9 in. wide alongside the driveway. Where this curb meets the level floor it should be tapered off, rather than being brought up and circled back in a scroll effect. This makes the approach to and the departure from the ramp much easier. It is desirable to have ramps laid out so that it is possible to describe a 60-ft. circle within the available ramp travel. If a 65-ft. circle can be provided, this is more desirable, although ramps can be used which lie just within a circle of 55 ft.

The grading of the ramp approach has not received sufficient attention in many cases. If possible, the division line of the flat floor and the ramp should be at right angles to the line of travel. This allows both front wheels and both rear wheels to enter or leave the ramp grade at the same time, which prevents the tendency toward an undesirable weaving of the car.

It seems formerly to have been thought more or less necessary to have what is now regarded as excessive story-height. On floors above the street level, it should be possible to keep the story height to 10 ft. 6 in. between successive finished floors, or but slightly more. The points in favor of lower story-height are decreased building cost, lower heating cost, better artificial light at the same cost, shorter and easier ramp grades, the possibility of more floors if the building height is limited, and the saving of time in driving from the street level to the upper floors.

Outside Doors, Pipe Wells and Elevators

The problem of outsde doors has received considerable attention. Many types are available, including vertical sliding, roll-up steel, single horizontal sliding, multiple-section horizontal sliding with sections moving at the same or at different speeds, folding-up or jackknife, and swinging doors. It is assumed fairly that any garage operator who has had experience with vertically moving doors of any type would prefer to use some type of horizontal door. The vertical type is vastly more dangerous, and a public garage using this type of door without having accidents either to the doors or to the cars is almost unknown. The horizontal sliding type of door, with plenty of glass to afford clear visibility, is undoubtedly the best available today.

Most doors of modern garages are power-operated, usually by electricity. The operating buttons can be placed so that the doors can be opened from several points, but the closing operation should be handled only from a point at which it is necessary for the person operating the closing button to face the door during the entire time of closing. Pass doors for pedestrians, when built into the large doors, should be provided with a safety switch that will prevent the operation of the large door if the pass door is not completely closed. This is an effective means of preventing serious injury to persons passing through.

It is desirable to provide a pipe well or a series of floor sleeves from the lower floor to the upper floor. In case of any later additions of pipes, conduits and wires to be run between floors, this will obviate cutting through the concrete floor. Another desirable feature is a dirt chute extending from the top floor to the basement, with openings on all floors, to provide for rapid disposal of sweepings and waste paper.

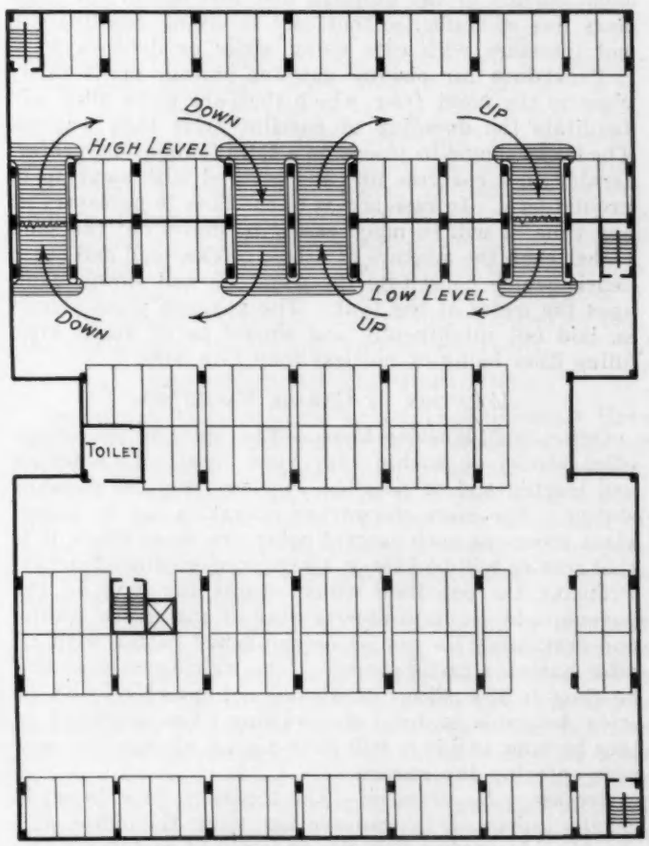


FIG. 6—TANDEM TYPE OF RAMP

This Type Consists of Two Single Ramps Somewhat Separated So That Two Lines of Traffic Do Not Interfere. One Ramp Is Used for Upward and the Other for Downward Traffic

The most popular type of passenger elevator for garages seems to be the one adapted to dual operation. When an operator is available it can be handled in the conventional way and, when the load is light and an operator is not needed, push-button operation will suffice. The elevators should have self-closing doors, both inside and outside. A novel type of elevator used for transportation of garage employes is the continuous-belt escalator equipped with steps and with handles on the belt. This runs in an enclosure having openings at each floor-level so that the men can step off or on. The belt is operated continuously at a speed of about 75 ft. per min. It is equipped with certain safety devices to stop the belt in case an employe should forget to step off and should start to go over the top. Considerable care, it will be seen, is necessary in the use of this elevator.

A ready means of providing for downward interfloor transportation of employes is the sliding pole. One pole extends between two adjacent floors through a circular opening of about 3-ft. diameter. A few feet distant is another pole hole and pole leading to the next floor below. Descent is thus limited to one floor at a time.

Provision for Dispensing Gasoline Equipment

Only a few fundamental considerations will be mentioned in regard to gasoline-dispensing equipment insofar as it affects the building design. In general, it is desirable to have the filling of gasoline tanks on cars done outside of the building and just out of the ordinary line of traffic, so that cars receiving gasoline will not interfere with cars using aisles or driveways.

Provisions for placing gasoline storage-tanks fairly close to the point from which they are to be filled will facilitate the dumping of gasoline from tank wagons. The tanks should be placed on a solid foundation, preferferably in a concrete pit, and covered with sand up to ground level. In case access to the tank is necessary at any time, it will be much easier to shovel out the sand rather than the mixture of ashes, bricks, mud and other debris which constitute the usual fill and slowly damages the metal of the tank. The gasoline pipes should be laid out intelligently and should be of ample size, filling lines being of not less than 2-in. size.

Location of Garage Facilities

Office and Waiting-Room.—The garage operating-office should be within easy view from cars entering and leaving and, if possible, in view from the gasoline station. The more the garage operation can be supervised from one such central point, the more likely it is that service will be kept at a higher operating efficiency. Probably the one item which counts for most in the garage is the prompt ascertaining of customers' wants, and certainly this can be accomplished better with an office having a broad outlook. The waiting-room should be close to the office, but should not interfere with it. It is desirable to have the waiting-room arranged so that persons inside it will have a view of cars and persons entering the garage.

Accessory Department.—The accessory department is usually operated in conjunction with the office and should be located so that the majority of customers will pass through it on their way in and out of the garage on foot. It is also desirable to have the location such that cars being driven in and out will afford their drivers a general view of the department. The particular advantage of locating the department close to the office is that, during the hours when little business is transacted, there can be a consolidation of supervision, at the same time giving garage patrons the advantage of having the accessory department open 24 hr. per day.

Repair Shop.—As natural light is very helpful in making mechanical repairs, a shop location on an upper floor is as a rule the most desirable. If possible, repair shops should be laid out so that the rows of cars that are being worked upon can be headed toward or backed up to walls having outside windows. Provisions should be made for a stockroom near the repair shop or for a dumb-waiter leading to a stockroom located elsewhere. Electric outlets should be provided for all electrically driven machine-tools. It is advisable, as a rule, to have the battery department and lubrication department very close to the shop. This should be considered in the layout. The practice of raising cars rather than to use pits is no doubt becoming more general. To provide for this, it is necessary to have a ceiling height sufficient to allow a car to be raised at least 4 ft. without interference from overhead pipes and other constructions.

Wash-Stands.—Probably the best location for car-washing stands is on the upper floors, since there is often a possibility of obtaining overhead light from skylights and such location makes a desirable use of space that is often thought less desirable for parking. Where a considerable amount of washing is done, it is advisable to make provisions for moving cars during the washing process. It is thus possible to have a continuous line of cars ready to put on the wash-stand as the washed cars are pushed ahead. It is an advantage to have space enough so that cars that have been washed can have the finishing operations performed close by, thus making it possible for one person to give adequate supervision to this whole department.

Tire Service.—Arrangements for tire service should be provided at a point fairly handy to the first floor, but the nature of this service is usually such that an out-of-the-way corner, insofar as car parking is concerned, can be used advantageously.

Considerations Affecting Garage Operation

In planning the equipment of a garage, careful choice of the proper items is essential. The test question which should be asked concerning each item of equipment contemplated is whether the piece of equipment can be kept busy. If so, it is cheap at almost any price. The idea behind every item of equipment should be the lightening or elimination of manual or mental labor.

One important decision in selecting gasoline equipment is whether provision shall be made for selling gasoline on all floors or on the main floor only. If it is to be sold on the upper floors, it can be done either through the medium of wheel tanks equipped with hand pumps or by means of an hydraulic or pressure installation. Many instances can be cited of garages elaborately equipped with gasoline-dispensing equipment but in which the sale of gasoline has not warranted the investment. The customer is interested in gasoline equipment only insofar as it speeds up delivery of gasoline to him.

One feature of the so-called wet-hose type of dispensing equipment is that the attendant has his hand on the control valve at the end of the hose during the filling operation, and spilling is almost eliminated. This wet-

hose type of equipment can be obtained with both the hydraulic and the power-pump systems.

One necessary item of gasoline-dispensing equipment is the safety can. The later types having flexible hose through which the can is emptied are rapidly superseding the earlier types which require the use of a funnel. Garages expecting to give satisfactory service to customers must keep an adequate supply of safety cans on hand for motorists who need gasoline in emergencies on the road.

A very useful and novel gasoline accessory is a liquid gage which can be mounted in the garage office and be connected with any number of storage tanks so as to indicate accurately the contents of each tank.

Three general methods are in use for dispensing oil. The bottle method involves the filling of 1-qt. glass bottles and placing them in racks where they are quickly and easily obtained by the attendant. This method is very satisfactory for checking the oil when bottles are filled at a certain point under proper control. The pump method makes use of either a stationary or a portable tank and, in the case of the latter, the oil is pumped either into a measure or directly into the crankcase of the car. The stationary-pump system allows the oil to be stored in a basement or in an out-of-the-way room and tends to make the handling of the oil much easier for the employes and more satisfactory to the customers.

Probably the best method of dispensing oil is through the pressure system, in which the individual oil-tanks are located either in the basement and are under air pressure or on an upper floor and discharged by gravity. The pressure system has the one disadvantage that the quantity of oil dispensed is not easily checked, but it is probably the quickest method.

For proper merchandising of accessories, it is necessary to provide adequate show-cases and counters, preferably in combination. Shelves must be provided to allow for the neat and compact storage of supplies. Special attention should be paid to the handling of such items as lamp bulbs, hose, fan-belts, and copper-gaskets, so that they will be kept in orderly arrangement, in good condition, and be quickly available. The manufacturers of various articles sold through garages have done good work in the last few years in providing means for their proper handling.

Washing Equipment and Problems

Washing equipment and problems constitute a broad subject. Many so-called washing-machines are on the market but the name is a misnomer; a high-pressure water-pump is usually meant, and it ordinarily is capable of producing a pressure of about 300 lb. per sq. in. The use of water forced under high pressure through a nozzle equipped with a ready means of controlling the stream has been one of the recent marked advances in garage service. The early types of pump available were an outgrowth of the pumps used for horticultural spraying.

The later types of high-pressure pump have been built specially for use in car-washing. They are simpler and require comparatively little attention. The piston type is probably the most popular, although the rotary type has fewer moving parts and is now beginning to come on the market in greater numbers. The displacement type, in which the plunger is not in contact with the cylinder-wall, gives very little trouble. Aside from lubrication, the only attention it requires is the simple operation of occasionally tightening the packing around the plunger.

Water-heating facilities come in the category of washing equipment. While many garages do not use warm water for car washing except during the coldest winter months, a car can be washed in less time and with less physical effort if the water is slightly warm. Hot water should not be used, as it injures the car finish.

There is a great variance of opinion as to the use of soap. It is well supported by experience that a neutral soap will not harm the finish if it is used so that particles of undissolved soap do not become imbedded in the sponge. Trouble has been caused either by unsuitable soap or lack of proper technique. It is unnecessary to leave a soapy application upon the finish of a car for any great length of time and, if an application of soapy solution is followed promptly with a good stream of water it will not be harmful. Most cases of so-called soap streaks are only "bloom," which forms upon cars when they are exposed to all kinds of weather and to the great variety of impurities in the air. This appears upon cars that are not regularly washed, and something more than washing with soap and water is necessary to remove it. The use of some body-cleaners and finishes, followed later by washing, will cause streaks which water will not remove.

The old method of draining all dirt washed from cars into an underground trap is being superseded in the newer garages by the use of improved traps in the wash-stands themselves. These traps allow the greater part of the dirt to settle before the water flows into the underground trap, and are easy to clean out frequently.

The washing of cars is one item of garage service in which there probably always will be a considerable element of manual labor if good results are to be obtained. So many corners and inaccessible places exist which are difficult to clean that it seems too much to expect to have this done entirely by automatic devices.

Adequate light for night washing can be provided by the installation of lamps having suitable reflectors, one at each corner of the wash-stand and at a height of 5 to 7 ft., possibly with one overhead light added so that the condition of the car tops can be seen easily.

Equipment for Tire Repairing

Important items required by a garage to render tire-repair service are air supply, tire changers, lifting jacks, air gages, tire-inspection machines and tube buffers. The hydraulic type of floor jack is generally liked by those who use it. It has the advantage of quiet and easy operation, it being necessary to operate the handle through only a very short range of movement to raise the car.

Tire-inspection machines, which spread a tire and render easy the thorough inspection of the inside, help in making repairs and promote the sale of tires when the customer can be shown that the old tire is seriously damaged. A tube buffer, which is a wire-brush mounted on a motor-driven shaft, is far ahead of the old style scraper or sand-paper for preparing the tubes for patching. The tire changer is an essential piece of equipment for handling properly the many types of rim and wheel in use today. One of the newer tire changers is operated by air, and is a great saver of time when handling split rims.

Every garage must have good air-pump equipment, and many reputable makes exist from which to choose. Adequate air storage should be provided. This will serve to reduce the number of times the air pump is called upon to start, as it is during the starting period that the greatest strain is thrown upon the pump and the motor. In a passenger-car garage, it is not necessary to maintain an air pressure greater than 125 lb. per sq. in. The cost of maintaining this lower pressure is much less than that for considerably higher pressures, which often are used but ordinarily are not necessary. Reels keep air hose off the floor and are very desirable. In its layout, a modern garage should be provided with adequate piping for air under pressure, with one air outlet for each 10,000 sq. ft. of floor storage-space.

Equipment for Miscellaneous Purposes

Time-clocks are essential so that an accurate record of the handling of the many transactions can be kept. They serve to place an absolute check upon the time a car is in the garage for storage, and thus eliminate the human element and the questions that customers may raise when an automatic record is not made.

Water stations placed near to but somewhat to one side of the line of travel are very desirable. They keep the water hose out of the way when not in use and make possible the filling of radiators without using water cans, which are easily misplaced or damaged.

The use of rough-service lamps in portable lights will prevent lamp breakage to a large extent. This type of lamp has the filament well supported and will withstand harder usage than the lamps ordinarily used.

Portable-stand lamps are useful for many operations around the garage, as they will furnish a concentrated light at points where it is needed temporarily.

The use of a tool board at some central location, on which all the tools used in ordinary garage work are displayed and made available for the employes, is one of the most useful items in the garage. It should be equipped with wrenches, cutters, chain tools, air gages, screw-drivers, hammers, pliers, electric lantern, rim wrenches, battery carriers and other such items. If the outline of each tool is painted on the board this will indicate what tools are missing. A system of tool checks will enable these tools to be kept under proper control.

The installation and use of a private telephone system is important as a means of quick communication with employes in different parts of the building. A telautograph, which transmits written messages electrically, has been used with good results in some cases. Pneumatic tubes for transmitting orders and charges are a useful adjunct to certain types of garage.

Battery, Emergency and Greasing Service

Every modern garage is called upon to render proper battery-service; that is, to test batteries, charge them and furnish rental batteries when necessary. The car builders have done very well in the standardizing of storage-battery sizes, and this enables the garage to give good rental service with comparatively few types of battery. Where any considerable amount of battery charging is done, the constant-potential type of charging generator is in great favor.

A completely equipped emergency car is a necessary piece of equipment. It should have a crane mounted so that a disabled car can be lifted and towed by either end, backward or forward. A ready means of lifting the front end of the newer types of car which have elaborate front aprons is the lifting hook recently brought out by at least one of the leading equipment manufacturers. When a car is towed by lifting the rear end, a set of steering clamps which hold the front wheels in a fixed position will be found of great assistance. Another important article for all-round use in a garage, and also for the emergency car, is a portable electric lantern, which is very inexpensive.

The use of pits inside garages is not allowed in Massachusetts, hence the use of lifts for elevating cars while they are being greased has become very general. It is considered essential to have the car up in the air so that the man doing the lubricating can have quick and ready access to all the under parts of the chassis. The newer types of greasing gun use air pressure in such a way as to put from 15 to 20 times the applied air-pressure on the grease that is being forced into the different places needing lubrication. A new type of grease pump is operated by air and will fill somewhat more than six transmissions or differentials without the addition of more air. This aids materially in keeping a greasing station clean, as there is much less opportunity of over-filling because the control is at the end of the hose.

In the lubricating operation, it is essential to see that the spring-shackle bolts are well lubricated and that, if they are tightened, they are not tightened so much that there is not perfect freedom of movement. Many broken springs are traceable to the over-tightening of spring bolts.

Records and Office Equipment

The importance of keeping adequate records in a garage cannot be over-emphasized. Within the last few years there has been a great improvement in many pieces of office equipment, and this has made record keeping easy. One of the most important articles is the cash register, which in its more improved types is a marvelous machine and a great saver of time. The rapid collection and sorting of charges from different departments is extremely necessary, especially where cash is handled at one central point. A telephone switchboard is necessary in every garage of any size.

Problems of Operation Involving Personnel

The most serious problem with which garage management is faced is the necessity for providing for operation during the 24 hr. of every day in the year. Unfortunately, the earning status of most garages does not make it possible to use three 8-hr. shifts of men. This difficulty has been surmounted in many ways, as by staggering shifts with men on duty for 11 hr. including meal time, which results in a smaller crew during a period of lighter load, this period usually coming between 1 and 7 a. m. It is sometimes possible to obtain part-time employes, especially where students can be employed during rush hours.

Offsetting the disadvantages of 24-hr. daily operation come certain advantages. A department store expects to do its daily business during a period of 8 hr. Some stores are open only half a day on Saturday and all are closed on Sunday. The garage has more than three times as many hours as does a department store in which to do business. If proper advantage is taken of

the sales opportunities of every hour of this longer business day, the reward will certainly make itself apparent. This means that there must be proper supervision of garage operations every hour of the day and night.

No garage is better than its personnel. In the garage of average size giving complete service there are at least 20 different classifications of employes. Particular care must be taken in selecting each man to determine whether his qualifications are adequate for the position to be filled. In general, the actual driving of cars must be left to the younger employes, because older men of the type who work in garages ordinarily do not drive well.

Among the other necessary qualifications for men in direct charge either of garages or of garage departments is the possession of a *natural mechanical sense*, because almost every operation in the garage is directly related to the science of mechanics.

A selection of properly qualified men enables a garage to offer complete service. Each man may be called upon to do many different kinds of work, including the driving of cars, acting as chauffeur, selling gasoline and oil, repairing tires, sweeping floors and other such tasks. Carrying departmentizing too far makes it difficult to keep men busy on one particular line of work.

The prompt reporting of any damage to customers' cars, whether caused inside the garage by employes or occurring outside and noted by the employes, must be insisted upon. It seems practically impossible to eliminate all loss and damage claims, but close attention to this matter will result in reducing them.

Other Problems of Operation

When opening a large garage, one of the important decisions for the operator to make is whether the place shall be operated as one garage or as several units, the usual unit in such case being one floor. Each method has its advantages; but a properly designed system should allow the operation from one source, adequate lobby and office space and ready means of communication between floors being provided. The assignment of the lower floors of a multi-story garage to cars driven by women may well be considered seriously. As a rule, women object more than men do to driving to the upper floors.

Every possible source of loss that can be covered by insurance should be considered. Accidents in which a garage may become involved usually are of an expensive nature. Too much care cannot be taken to minimize these losses.

After the selection of the personnel, the next largest problem is the selling of space, supplies and service. Selling involves the creation of new demands and the attempt to do for the motorist what he may theretofore have done for himself because of inability to obtain this form of service. Every successful garage strongly stresses selling as being *the very foundation of success.*

Scheduled lubrication, which provides for the car owner at stated intervals the exact care in the matter of lubrication which his car requires, is a fertile field for garage business. "Green-tag service," sometimes called "automatic service," whereby garages keep cars filled with gasoline and oil and give periodic attention to the battery, radiator and tires, is another means of increasing business. Prompt notification to the owner, preferably in writing, of any apparent or impending trouble with his car, is a good producer of business as well as of good-will.

In so-called slack seasons, special attention should be paid to every possible source of revenue through such procedures as tire inspection, battery inspection, inspection of mechanical condition, and the stressing of such seasonal items as make for winter protection and summer comfort. Referring to its sales curve, the watchword of the successful garage is "Fill up the valleys and push up the peaks."

Keen judgment is necessary at times to select profitable lines of endeavor for a garage. A safe rule is to start any new department on a small basis and let it build itself up, rather than to start in on a large scale without being certain of the business to be expected. It is vital that each department should stand on its own feet. If a department cannot make money, it should be discontinued rather than to attempt to carry it on in the belief that it is a necessity.

Specific Needs of the Garage Industry

The crying need of the garage industry is for better men, engineers if you please, with open minds, who consider facts rather than fancies, who are willing and ready to admit mistakes at the proper time and generous enough to give credit to others when credit is due. There is sore need of more associations which will study garage problems and afford a perfectly free interchange of experience and knowledge. Can one picture a group of bankers financing a factory to produce a new car and engaging engineers to design this car who have had no previous contact with the building of automobiles? But this sort of thing is going on repeatedly in the garage industry. Although this industry is of such vast proportions, not one book has been published which deals exclusively with garage problems.

We need more and better equipment to save additional time and labor in the different operations the garage is called upon to perform. We need garage buildings that cost less, because the high cost of many of our buildings is the answer to the lack of profits shown by these ventures. We need also the general recognition of the principle of looking for profits from operation, rather than from promotion, as the only correct basis upon which this industry can expand properly.

Future Trends and Possibilities

Garage buildings today are built largely of concrete and steel and are of such stability that the Government allows not less than 40 years in which to write off the investment completely. Is it not possible that these buildings will be out of date and consequently less valuable through obsolescence rather than through depreciation? Who is bold enough to predict what our mode of travel will be in 40 years?

A backward look over the trends for the last 10 to 15 years shows that cars are becoming shorter, lower, wider and lighter, as well as having a shorter turning-radius. Will these trends continue and, if so, how far? Ceiling heights thought proper 15 years ago are now extravagantly high. Spacing between columns that was thought just right 15 years ago is found too close today for cars having the wide fenders necessitated by balloon tires, and the trend is still increasing. Elevators of a capacity to lift 7000 or 8000-lb. cars are not needed today, even in the comparatively few newer garages which are equipped with elevators.

A careful survey among a great number of garages of the modern type shows an allotment of an average of 250 sq. ft. of floor area to each car stall. A car occupies, of itself, only 100 sq. ft. Is not this difference a real challenge to American inventive genius? The capitalization for each car space for city garages varies from $600 to $3,000. The garage is expected to yield a net operating gain of about 10 per cent on this capitalization, which amounts to from $60 to $300 per year. There is a vast difference between these two figures, but this makes all the more impressive the necessity for keeping down the capital cost to a point at which the lower figure may obtain. This means, among other equally essential considerations, the allotment of smaller floor-area to each car stall.

One of the primary functions of a downtown city garage is the parking of cars for short periods at low cost, thus relieving street traffic of its greatest enemy, parked cars. In the accomplishment of this function, adequate support by civic authorities should be insisted upon, thus leaving our streets open for the movement of traffic, the purpose for which they were built.

THE DISCUSSION

CHAIRMAN FRANK E. H. JOHNSON[2]:—In the operation of garages, what are the latest methods of eliminating carbon-monoxide gases resulting from the exhausts of engines?

GLENN S. WHITHAM:—Ozone mixtures are used in some service stations, but have not so far been used in garages. In a garage, comparatively few men work on the floor. The space is usually large and well ventilated, and engines are run only for short periods.

CHAIRMAN JOHNSON:—We experimented with an apparatus which generates ozone. The manufacturers claim that the ozone generated will not actually neutralize the carbon-monoxide in a room, but that the excess of oxygen with which the ozone supplies the air builds up in the human body resistance to carbon monoxide as well as having the beneficial effect of oxygen on the human system. We have used this apparatus for 3 years and have noticed that the workmen are quick to detect the difference if the apparatus becomes inoperative and to call for its repair. Apparently the ozone eliminates sick headaches.

In more modern buildings erected for our company within the last 2 years, however, we have installed the exhaust-fan type of ventilation because, generally speaking, we prefer that system. Incidentally, a steam-heating-system in which a fan is located behind a steam coil to blow the hot air out into a room works very well in connection with an exhaust-fan for clearing the atmosphere of gases. In a new building recently completed these heating units are located somewhat more than half way up to the ceiling; the fans are set on the floor on the opposite side of the room, openings being cut in the wall, and this gives an ideal circulation of the air. In summer the circulating fans can also be operated to provide cool air. Several companies of which I know use this ozone apparatus and find it satisfactory.

MR. WHITHAM:—The specifications for one garage now being planned for Boston call for a complete change of air every 5 min., and for forced ventilation and heating combined. The specifications call for maintaining an inside temperature of 50 deg. fahr. when the outside temperature is as low as 10 deg. fahr. below zero.

G. L. APPLEYARD[3]:—Our repair shop is on the third floor of a building which was not originally designed for garage work. We made an installation for removing gases from the exhaust of the engines by running 3-in. galvanized gutter-pipe along the ceilings of the second floor and using flexible-tube connections through the floor that can be attached to the exhaust pipe of an engine. If a workman operates an engine, he first attaches the flexible tube. A pilot light is used so that the men know when the blower fan is not working, the pilot being mounted conspicuously so that everyone can see it. In spite of this, the movement of the automobiles into the repair spaces was enough to give trouble due to gas in the room in cold weather when the windows and doors were closed, so we added two of the ozone machines but, as several more of these would have been needed and would have been expensive, we installed a 42-in. exhaust-system which was calculated to clear the air of the room in 3 min. At any time when the air becomes foul the exhaust system is used to clear the general atmosphere of the room. Before these precautions were taken seven of the men had to go home on one occasion at 3 p.m. suffering from headache caused by carbon-monoxide gas.

L. S. JOSLIN[4]:—Since carbon-monoxide gas is heavier than air and lies near the floor, it is not necessary, when changing the air at intervals of say 5 min., to change all the air of the garage. If the openings to the ventilating systems are located near the floor and have graduated openings connected with an exhaust-fan system, all that is needed is to draw the air from the lower part of the room without disturbing the good air which is near the ceiling.

CHAIRMAN JOHNSON:—Carbon-monoxide gas has a cumulative effect on the human system. The more a person breathes it, the more likely he is to feel its bad effects. In garages equipped with ramps, it is easier to induce good air-circulation throughout the building, since the carbon-monoxide gas tends to drift down the ramp and eventually to reach the street level, thus clearing the air on the upper floors.

One more point in garage work is to prevent soap and kerosene reaching the brake-linings while cars are going through the washing process. A good method of prevention is to lock the brake-pedal down so that the gap between the brake-lining and the drum is closed.

OIL-DISPENSING EQUIPMENT

R. M. DONAHUE:—Will Mr. Whitham describe more fully the oil-dispensing equipment he mentioned?

MR. WHITHAM:—The equipment is suited mainly to multiple-floor garages. Several different tanks of oil are located on the upper floors and the oil flows down through pipes having different outlets located conveniently. One advantage is that the oil flows rapidly, but a disadvantage is that it is difficult to check up on the amount of oil consumed.

[2] M.S.A.E.—General service manager, Noyes Buick Co., Boston.
[3] M.S.A.E.—Service manager, Robinson-Toohey Co., Lawrence, Mass.
[4] Consulting garage architect, Joslin Motor Ramp Co., Boston.

MR. DONAHUE:—When two or three different shifts of men are using the oil, we have found that the best method of recording oil consumption is to use standard-sized bottles as containers. Each shift of men is allowed a certain number of bottles of oil and is held responsible for the oil used.

MR. WHITHAM:—When the bottles can be filled at a central tank and turned over to the direct charge of certain men who are held responsible for them, this is the most accurate method of accounting for the oil used.

RALPH W. YOUNG[5]:—The bottle system seems to be universally accepted in the New England district. One company of which I know changed its system from that of storage tanks located on an upper floor with gravity feed through piping to the storage floor, and located the oil tanks in the basement and on the first floor as filling stations for the bottles. A certain number of bottles of oil were issued daily to the men and they were held responsible for them.

CHASSIS-LUBRICATING EQUIPMENT

MR. DONAHUE:—Does the air-pressure chassis-lubricating equipment Mr. Whitham mentioned give much trouble from breakdown of the hose and grease leakage caused by the pressure?

MR. WHITHAM:—One difficulty is that the pumps sometimes build up excessive pressure and force the grease right through the hose. The remedy is to use a reducing valve to lower the air pressure and to avoid using the hose for too long a time. No difficulty seems to arise from excessive air-leaks.

MR. DONAHUE:—Is there not at present a growing tendency to use lighter oil?

MR. WHITHAM:—I believe there is.

ALBERT LODGE[6]:—Most of the trouble is due to hose that is not strong enough. The hose seems to be designed fairly well, but wears under the strain of the constant pressure. It is woven and some parts are weak. We find that grease hose gives satisfactory service for a short time only. There is a large field for a properly designed flexible hose for greasing chassis parts. Hose used for greasing does not break out in one place but leaks grease all over.

CHAIRMAN JOHNSON:—Hose under pressure breaks down because of continuous bending, which will eventually cause it to leak. If the hose is led to the various parts of the chassis without any excessively sharp bends and if it is equipped with the flexible joints now available, its failure can be virtually eliminated. In one instance I observed that grease is led to a central point under the car and the hose is carried from that location to the various parts with the minimum amount of bending.

MR. LODGE:—I have seen numerous installations in which the pressure is reduced and is carried in a hose or pipe which is not flexible but is equipped with numerous outlets, the connection to the part that is to be lubricated being made by short tubes; that is, instead of carrying the pressure for a long distance through a flexible hose. On some installations, I have observed 21 outlets, and the pressure was carried through pipe a maximum distance of 140 ft. to the point of delivery. The system worked very successfully.

In one station at Columbus, Ohio, cars were run in on two levels, and five cars at a time could be greased on each level. In 1½ hr., six men greased 40 cars. I noticed that one man changed his flexible hose to five different outlets while greasing one car, his reason being that it is better to use short lines and make numerous connections than to use one long flexible hose.

CHAIRMAN JOHNSON:—That seems to verify the statement that it is the bending of the hose which tends to cause it to break down.

MR. LODGE:—It seems so. They tried the short sections with six joints spaced 1 ft. between the links and discarded such equipment because it was too heavy. They changed back to the original type of woven flexible hose.

QUESTION:—Were they using gear oil or cup grease?

MR. LODGE:—Cup grease. They discarded gear oil altogether.

MR. APPLEYARD:—For greasing, we use 16 piped outlets to which we couple the high-pressure pumps. A flexible hose that will stand up under hard service is greatly needed for connection to pumps in service-station work. Our men tow the pumps by their hoses from one outlet to another and the hose will not withstand such abuse.

In some cases in which high pressure is used, the universal-joint covers are blown back so that a streak of grease is thrown under the body of the car. We are seeking a special lubricant partaking somewhat of the nature of gear oil but more fibrous; something that will be an improvement over plain gear-oil and that can be fed through a high-pressure gun.

GAGE FOR MEASURING LIQUID IN TANKS

CHAIRMAN JOHNSON:—Will Mr. Holmes describe the gasoline-checking system in which he is interested?

R. J. HOLMES[7]:—This liquid gage was designed to measure accurately gasoline, kerosene or any volatile liquid having a specific gravity of not more than 75 or less than 25 deg. Baumé. It will check the liquid contents of any given number of bulk storage-tanks, or of underground storage-tanks. It will measure accurately the contents of a tank-car after discharging into a bulk storage-tank, and will check the contents of tank-trucks hauling liquid away from bulk storage. If installed in service stations it will check the meters on gasoline pumps, and the daily sales records against the cash register.

The gage is installed at some central point such as in an office. Each tank is connected to the gage by copper tubing. In the gage shown in Fig. 7 is a horizontal mercury column, *a*. A valve manifold, *b*, is underneath. A separate copper tube, *c*, leads to each tank, and the measuring device *d* extends into the tank. The figures on the dial *e* represent 72 in. of liquid in the tank, each inch being divided into tenths. This device gives accurate measurement as closely as the tank manufacturer can determine the exact contents of the tank he makes.

After a reading is taken in inches and tenths of inches, the chart supplied by the tank manufacturer is consulted, and the liquid level in inches is converted into gallons. To assure an accurate reading, the gravity of the liquid should be known, as the gage is calibrated to 58 deg. Baumé. For liquid heavier or lighter than this, the correction chart we supply should be used to get an accurate reading.

[5] Standard Oil Co. of Boston, Boston.
[6] M.S.A.E.—Service engineer, Charles Street Garage Co., Boston.
[7] Division manager, Fry Equipment Corporation, Boston.

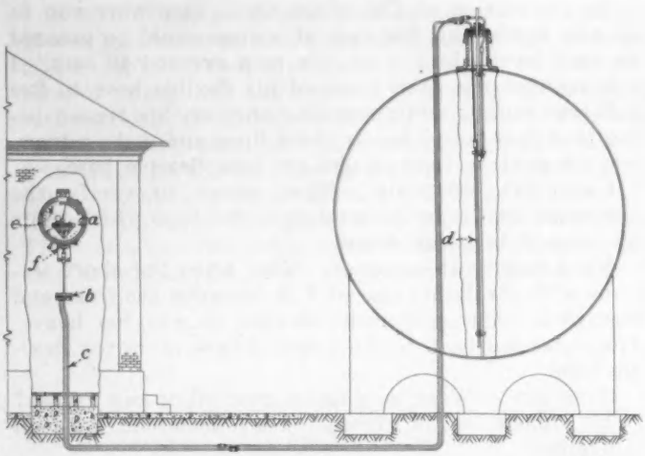


FIG. 7—GAGE FOR THE ACCURATE MEASUREMENT OF LIQUIDS

The Gage Is Installed at Some Central Point, as in an Office. Each Storage Tank Is Connected to the Gage by Copper Tubing. The Principle of Operation Is That of Balancing the Pressure of a Liquid Against a Column of Mercury, Which Is Inside the Gage, as Indicated by *a*. A Valve Manifold, *b*, Is Provided and a Separate Copper Tube, *c*, Leads from This Manifold to Each Storage Tank. The Measuring Device *d* Extends into the Tank. The Figures on the Dial *e* Represent 72 In. of Liquid in the Tank, Each Inch Being Divided into Tenths. A Small Hand-Pump, *f*, Is Attached to the Gage, and by Means of It the Tube to any Specified Tank Can Be Filled with Air, thus Expelling the Liquid from the Tube in the Tank and Leaving an Air Cushion from the Bottom of the Tubing to the Gage. After a Reading Is Taken in Inches and Tenths of Inches, the Reading of the Liquid Level in Inches Is Converted into Gallons by Means of the Chart Supplied by the Manufacturer of the Tank

Attached to the gage is a small hand-pump, *f*. To get a reading of the liquid in any desired tank, the valve on the manifold which opens the tube leading to the desired tank is opened and a few strokes are given with the hand pump. This fills the tubing with air, expels the gasoline from the tubing in the tank, and leaves an air cushion from the bottom of the tubing to the gage. The weight of the liquid pressing against the air cushion, which in turn presses against the mercury in the gage, causes the dial hand to indicate the required depth of the liquid in inches.

The principle of the liquid gage is simply that of balancing the pressure of the liquid against a column of mercury. It is simple, has no moving parts and is accurate. It is our company's contribution to the elimination of inaccurate measurement of liquids.

JOSLIN TYPES OF RAMP

A. W. HANINGTON:—Are any statistics available as to the percentage of floor area that is occupied by your various styles of ramp?

MR. JOSLIN:—The percentage of floor area occupied by the ramps varies with each different garage, depending on the amount of land covered by the garage and other factors. The statement has been made that 10 ft. 6 in. is high enough from top to top of floors. This is true in some cases where the floor construction is of the flat-slab type, the slabs being 7 or 8 in. thick; but, with wide spaces for car stalls and aisles, it is not always feasible to use the flat-slab construction. The most common construction of floors in large garages is what is known as a beam-and-girder construction. The longer the spans are, the greater is the depth of the beams and girders. The proper way to determine the distance from top to top of floors is to allow at least 8 ft. 6 in. clear space under the low girders and to add to this the depth required by the girders or beams that project lowest. This height will give room to place under the low beams any pipes, such as oil and sprinkler pipes, and leave ample height for cars to pass underneath without interference.

In a model of our duplex system of ramps made to scale, the story height from top to top of floors represents 12 ft. The represented length of the ramp is 91 ft. 6 in., which gives a ramp of 13.1-per cent grade, or 12.5-per cent grade for an 11 ft. 6 in. height from top to top of floors.

No one system of ramps solves all garage problems, but there is always one system of ramps that is the best for each individual problem. Circular ramps require more floor area than straight ramps, as they must be made a great deal wider to allow for the swing of a car, and the space around a circular ramp is not as available for parking cars as is that around a straight ramp. The width of a straight ramp between columns should be 10 ft., and it should widen out at the floor line in the direction in which the cars turn. This makes it much easier to drive in and out of the ramps than to make a 90-deg. turn on the floor at the head and foot of each ramp.

The columns in a garage must be spaced so as to give proper car storage, aisles and turning spaces. Sometimes the design will work out with two, three or four car-spaces between columns. In my opinion the three-car space is the most desirable and economical from all points of view.

In a garage suitable for trucks, the conditions are different. The truck garage must be built for heavier loads, the story heights must be greater, the ramps wider and longer and have less pitch, the parking spaces must be deeper, the aisles wider, and the turning spaces greater than in a passenger-car garage.

Our duplex system of ramps was installed in the Motor Mart in Boston. This system allows two lines of cars to ascend and two to descend at the same time. In this garage, at no time are cars driving toward each other; they are always driving in the same direction. These ramps have a 13.5-per cent grade from the street floor to the second floor, due to the extra height of the first story; and a 10.0-per cent grade from the second to the eighth floors. These ramps take up 1000 sq. ft. less floor space than the circular ramps in the Eliot Street Garage, yet they do twice the work.

It is possible with our duplex ramps to have four lines of ascending or descending cars at the same time. In one day at the Motor Mart, 3500 cars were driven in and out without the least confusion or trouble. If enough elevators were installed in the Motor Mart to do the work of the ramps, there would not be much space left for parking cars.

In our simplex system, the ramps extend from floor to floor and are pitched diagonally opposite each other. The cars go up and down in two separate and distinct zones, one line turning to the left and the other to the right. This is a distinct advantage, as it eliminates the driving of cars toward each other, reduces the number of accidents and speeds up operation. The amount of space taken up by the simplex system is only one-half that required by the duplex system.

MR. WHITHAM:—What is the maximum grade allowable for a ramp?

MR. JOSLIN:—In my opinion 12.5 or 13.0 per cent is the maximum that should be allowed; 10 per cent is better, but 15 per cent is the limit of safety and should not be used unless there are clear wide aisles at the top and the bottom of the ramps. The narrower the aisles are, the less is the percentage of grade which should be maintained on the ramps. In practically all staggered-floor garages, the length of the ramp is restricted to the length of two car-stalls plus the thickness of the dividing wall. In general, the horizontal length is from 31 to 33 ft., which usually works out to a 15 or 16-per cent grade on the ramps. The ramps in a staggered-floor building require twice as much turning and a greater distance to travel than in garages where the ramps extend from floor to floor when the floors are level.

Beauty's Place in Business

IF you were to divide the history of business during the last half-century into 10-year periods, and then examine the chief factor of progress in each, I believe you would find that a different type of man has influenced industrial development in each of these last five decades. I believe that a table of the type of men who have most profoundly influenced the progress of industry during these 50 years would look something like this:

1880-1890—The inventor
1890-1900—The engineer
1900-1910—The salesman
1910-1920—The advertising writer
1920-1930—The artist

Fifty years ago people bought what they wanted when they wanted it and how and where they wanted it. There was little or no coercion or cajoling on the part of either the manufacturer or the merchant. The manufacturer made things and the merchant stocked things for people to buy. What we now call selling was practically unknown.

The application of inventiveness and the harnessing of power suddenly speeded up production and at once we were pitchforked into a new situation—cheaper goods—more goods—competition for outlets for the goods—the necessity for selling, instead of waiting for people to buy.

But the drummer, as the sole means of selling, did not last very long. His footwork was soon seen to be as uneconomic as the handwork of the laborer. Mass production of salesmanship—selling in print to millions—overtook him even more quickly than did mass production in the factories. The flood of oratory was stopped, and the deluge of printed words began.

The day of the printed word was even briefer. The plain type-advertisement was quickly dubbed uneconomic also. It did not work fast enough. Pictures convey a message more immediately than words, said the advertisers. And the artist was called in.

All this, of course, in the name of speed and economy. That, so far, has been the main excuse for the artist in business. His pictures are the fastest means yet devised for selling as fast as possible the goods that are made as fast as possible. Life is short, but art—and this the business man hadn't quite reckoned on—art is long!

BEAUTY WILL BE MASTER

This hireling, Beauty, is already master in Business, and in the end will master it altogether. Look at what happened almost at once. Advertising became more beautiful, and, as soon as that occurred, the products around which the advertising shed its glamor came to look crude, garish, common. That was quite unforeseen; but something had to be done about it immediately. Designers were hired to produce handsomer furniture, period phonographs, streamline cars, artistic fabrics, prettier chocolate boxes. Then color crept into merchandise, as it had a little earlier crept into advertising. Color assumed the rôle of master, and manufacturers quickly responded to its dictates with colorful cars, washing-machines, fountain-pens, beds, typewriters, oil-stoves and goodness knows what.

The imagination of the manufacturer and merchandiser travels in the direction of utility and economy. The imagination of the artist travels in the direction of beauty. The artists engaged in advertising could and did visualize automobiles handsomer than any that had yet been made, and some hint of this non-existent beauty got into their roughs and was even allowed to stay in some of their finished drawings. The new models in the artist's imagination had to be put into production. And where beauty is concerned the artist is always ahead of the business man, beckoning him on to new creations.

And so, to the race for utility and endurance and speed and safety, there has been added the race for beauty. Of course, beauty is not a quality that stays put, like utility. People do not tire of the use of things, but they do tire of their appearance. The moment you introduce the *possibility* of beauty into an article formerly regarded as purely utilitarian. the possibility must be *actualized*, for once given a taste of beauty we demand more and more.

FICKLE STYLE'S GRIP

And the worst, it seems, is yet to come. Style—that by-product of beauty—has already affected a great many lines, but some few manufacturers have so far been able to sidestep it. They will not do so much longer. Within a few years there will hardly be an article in common use that is not influenced, and quickly, by style changes.

There seems to be no help for it. Business, for a while at least, is going to be ruled by that fickle jade, Beauty, with her emotionalism and her wild whims and her soft answers. The artist is going to strut the stage for a bit, while all the old-timers hoot and hiss. And Beauty will be revenged upon Industry for all the smoke that has befouled her cities, and for all the cooped and crippled lives that have been sweated away in her prisons of production.
—Bertram R. Brooker, in *Printers' Ink*.

The Packard X 24-Cylinder 1500-Hp. Water-Cooled Aircraft Engine

By L. M. WOOLSON[1]

NEW ENGLAND SECTION PAPER *Illustrated with* PHOTOGRAPHS AND DIAGRAMS

AFTER outlining the history of development of the Packard X engine, the author states the legitimate position in aviation deserved by the water-cooled aviation-engine of this type and predicts large increases in the size, speed and carrying capacity of airplanes within the near future. Passing then to a discussion of the important features of the X-type engine, various illustrations of its parts are commented upon.

The cylinders are built-up from steel forgings, with all welds arranged so as to be subjected to no excessive alternating stresses. The novel features of this cylinder design lie in the fact that the valve seats are entirely surrounded by water and that water space is provided above the combustion-chamber and below the top plate of the cylinder. The cylinder-head is extremely rigid, resisting deflection and assuring the maximum integrity of valve seats. The valve ports are machined integrally with the cylinder-head and are not welded thereto as in the Liberty engine.

The arrangement for obtaining a controlled circulation of exhaust gases around the inlet manifold, a short passage communicating between the exhaust port and the jacket surrounding the inlet manifold, and features of the design of the piston are described. In the former, two small drilled plugs are provided which, under idling conditions, induce a considerable flow of exhaust gases around the inlet manifold and into the mixture, thereby promoting good distribution under idling and throttled operating conditions. The piston design incorporates extremely short skirts, the over-all length of the pistons being 3.164 in. for a diameter of 5.375 in.

Crankcase, crankshaft and other mechanical parts are enumerated. The engine control is illustrated and described. Mention is made of the experimental, acceptance and flight tests, with a brief description of the procedure, and a curve is presented which shows the increase in airplane speed in the last 22 years.

In conclusion, the author advocates governmental aid for airplane development work, since the Government alone possesses the needed skilled specialists and the elaborate testing-equipment required.

DEVELOPMENT of the Packard X engine began about 8 years ago, when powerplants for the dirigible Shenandoah were first being considered. It was decided to use six-cylinder-in-line engines, which were heavy. Originally, the Shenandoah was equipped with six engines, each developing 300 b.hp. and each weighing approximately 1200 lb. Our Model-2500 engine, rated at 800-hp. and weighing substantially the same as the foregoing 300-hp. engine, was being developed at the time the Shenandoah was wrecked. With a conservative rating of 600 hp., it would have cut down the powerplant weight approximately one-half. Comparing the present Packard X engine with the five engines used on the Shenandoah during most of her flights, it weighs approximately 1500 lb., develops approximately 1500 hp., and could have replaced all five of the former engines at approximately 25 per cent of their combined weight.

The engine borrowed from the Navy Department and used by Lieut. Alford J. Williams, U.S.N., for obtaining flight experience and for powering the special plane in which he tried to win the world's speed record, was not equipped with a supercharger. The unsupercharged engine developed 1250 hp. at 2750 r.p.m. and weighed slightly less than 1400 lb. During the 30 hr. of operation to which this engine was subjected, mostly at racing speed, at no time was mechanical trouble experienced or adjustments of any kind made. It is planned to substitute the supercharged engine in the plane later, it being obvious that the speed will thereby be considerably increased. The engine develops about 160 hp. per sq. ft. of frontal area.

During the last year or two, aviation authorities have been prone to overlook basic requirements of powerplants in respect to their frontal area. It is a fact that a 200-hp. radial air-cooled engine cowled into a cabin plane makes a very excellent combination. The projecting cylinders in this case do not constitute such a grave additional resistance as they would in the case of a fuselage of smaller dimensions. On the other hand, a 200-hp. engine is naturally limited as to the load which it can be expected to carry. The record—set, I believe, by the late Mrs. Grayson in a certain flight—amounted to 6000 lb. per engine or a loading of about 30 lb. per hp. which I think is a world's record for planes outside of the light-plane class. Applying this same ratio to our X-type engine, it should be capable of taking into the air a plane weighing 45,000 lb., which is, I believe, larger than anything yet built. Small radial air-cooled engines are very well adapted for moderate loads; but, as the demand grows for heavier loads and higher speeds, much larger engines will be required, and they must be suitable for well-streamlined fuselages.

INCREASED SIZE, SPEEDS AND LOADS PREDICTED

It is not intended that this paper should discuss air-cooled engines versus water-cooled engines, but it is necessary to demonstrate clearly at this time the legitimate position in aviation deserved by the water-cooled aviation-engine of the X type.

Recently, I have heard of three separate projects considering the use of no less than 10,000 hp. in a single

[1] M.S.A.E.—Aeronautical and research engineer, Packard Motor Car Co., Detroit.

plane, and I consider such designs as indicative of what we may expect in the future. The designs of these tremendously large planes are all of the thick-wing cantilever monoplane type, with cabins and engine rooms enclosed in the wings. The designs include multiple powerplants, in some cases with tractor propellers mounted in front of the leading edge and in other cases with pusher propellers aft of the trailing edge. Although such designs seem fantastic to us at present, we must realize that the general traveling public will not be able to take advantage of aerial transportation on a large scale until such planes actually are built and are operating safely. Last year one man with superb courage proved that he could cross the Atlantic alone in a flight from New York to Paris. That was a very thrilling episode but, so far as public utilization of air travel is concerned, we need planes capable of crossing the Atlantic with at least 100 passengers. Such planes will demand enormously powerful engines, and it is inconceivable that the great parasitic-resistance of many externally mounted air-cooled powerplants can be permitted. Further, the need for convenient access to the engine for minor repairs and adjustments during flight will also require that the engines be suitably housed within the wing, which leads naturally to the conclusion that the engines should be water-cooled.

An additional good reason for the use of the water-cooled engine relates to ice formation on the wings and fuselages of planes, which is recognized as a serious handicap in transatlantic flights. While it is perhaps too early to make a positive assertion of this nature, it seems that if the plane were equipped with the wing-skin type of radiator it would be feasible to prevent ice formation, especially since it has been shown that the dangerous effects of this phenomenon are confined to restricted portions of the wings, notably at the leading edge. The danger is believed to exist only within a rather limited range of temperature and an equally limited zone of saturation of the atmosphere with water vapor. Presumably, ice is formed as a result of either absorption of latent heat through evaporation on such surfaces of the wings as are subjected to sub-atmospheric pressures or of local increase in pressures which, occurring in a saturated atmosphere, naturally would result in condensation. Regardless of the cause, the problem is definitely with us, and its solution cannot be shirked if we are to have year-round flying over all conceivable routes. In this connection it should be realized that the formation of ice is not confined to the surfaces of the wings; it also takes place on all exposed parts of the airplane, including the propeller blades.

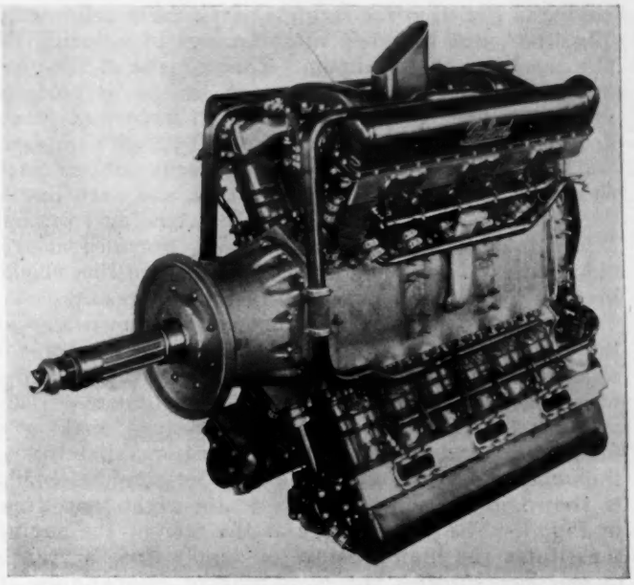


FIG. 2—PACKARD X ENGINE SHOWING THE THREE PADS ON THE CRANKCASE TO WHICH THE LANDING-GEAR AND THE FUSELAGE ARE BOLTED

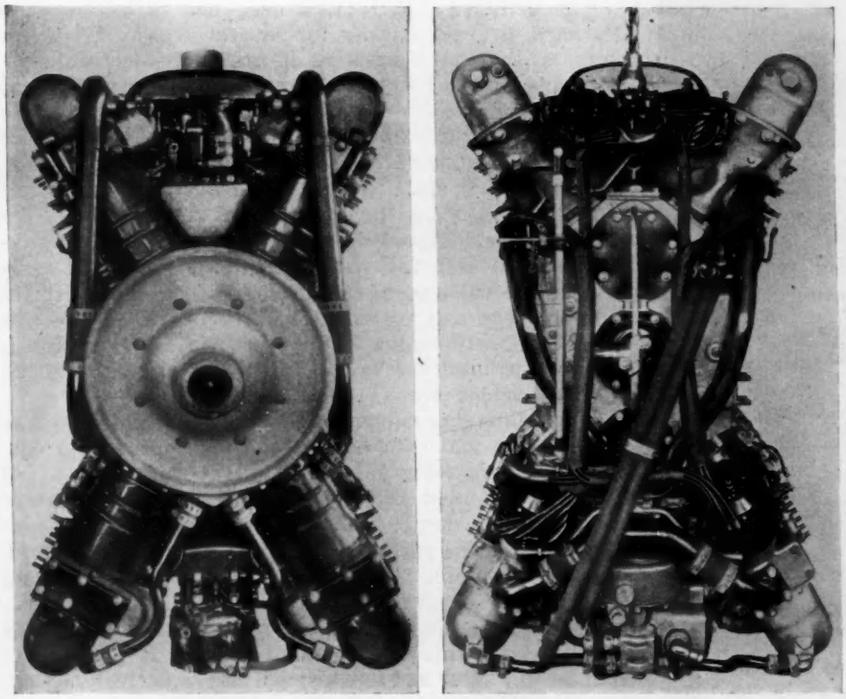


FIG. 1—FRONT AND REAR VIEWS OF THE PACKARD X ENGINE

Although many aeronautic authorities are agreed on the feasibility of the giant thick-wing monoplane, progress in this direction naturally is hampered by the enormous amount of money required for such an undertaking. In this respect the situation is very similar to that of large dirigible development, which is being greatly retarded by difficulty in interesting capital in such ventures. One of the chief reasons for the rapidity in growth of commercial aviation along present lines is that such planes as are now being used can be built for a very modest expenditure, such as $15,000 or $20,000, and it would require 200 or 300 times as much money to construct a large dirigible or an airplane of the vast size contemplated.

The installation of the gasoline lines shown in the rear view of the

engine in Fig. 1, at the right, is particularly noteworthy. The lines were designed with the idea of reducing the fire hazard to the minimum. They consist of one-piece annealed copper pipes having no brazed or soldered fittings or flaring operations. At all important points drop-forged-steel fittings are provided, with integral "olives" or protecting sleeves to prevent rubber particles from entering the gasoline lines, and each line is enclosed in a one-piece rubber hose extending from one fitting to another, hose clamps being provided at frequent intervals so that, even if a gasoline line should break, no external leakage of fuel would result.

The battery ignition distributors are shown also at the right in Fig. 1. Four 12-cylinder distributors of conventional design are used, each distributor being wired to two of the four banks of cylinders. Each cylinder is provided with two spark-plugs, making a total of 48, and a high order of ignition reliability is thus obtained. The oil, fuel and water-pump assembly is shown in the lower portion of the right-hand view in Fig. 1. The vertical pipe at the rear of the engine constitutes the high-pressure oil-supply line; a branch to the left supplies the main-bearing oil-manifold at reduced pressure. The vertical control-shaft at the left operates all four carbureter-throttles as well as the spark-advance control of the four distributors, and the peculiar method in which this is connected up will be described later.

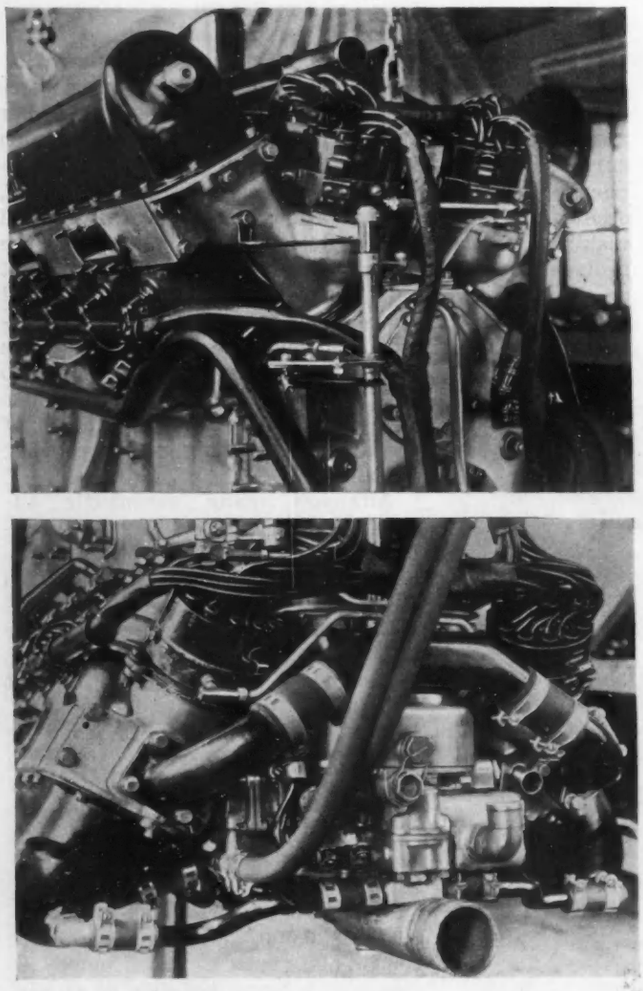


FIG. 3—DETAIL VIEWS OF THE PACKARD X ENGINE
The Method of Pilot-Control Hook-Up Is Shown in the Upper View. The Most Congested Portion of the Engine Is Illustrated in the Lower View

A front view of the engine without the supercharger is shown at the left in Fig. 1. The supercharger does not increase the frontal area of the engine, in spite of the fact that it contributes about 200 hp. additional. The forward part of the engine cowling is fastened to the circular plate attached to the front end of the propeller-shaft housing. No trouble was experienced with the cowling support during flight tests, although previously it had been considered bad practice to attach cowling to the engine at any point. In this particular case, absence of trouble is explained by the smoothness with which this engine operates.

In Fig. 2 will be noted the three pads on the side of the crankcase to which the landing-gear and the fuselage are bolted. It is strictly true that in this installation the engine crankcase forms the foundation, as it were, of the whole airplane structure, and the front landing-gear struts are attached to fittings which are bolted directly to the front pair of pads. The rear two sets of pads constitute the points of attachment of brackets to which are attached struts leading back to fittings bolted at the firewall or front fuselage-bulkhead and to four longerons that form the ribs of the monocoque fuselage. The upper view in Fig. 3 indicates the method of pilot-control hook-up. The lower view in Fig. 3 reveals the most congested portion of the engine; that including the water-pump, the fuel-pump and four oil-pumps. Although there is very little clearance between the various units, care has been taken to provide ample accessibility to all the pipe connections needed to connect the various systems with corresponding piping in the plane.

METHOD OF CYLINDER CONSTRUCTION

The cylinder construction used has been typical of Packard aircraft engines for several years. The cylinders, as indicated in Fig. 4, are built-up from steel forgings welded together, with all welds arranged so as to be subjected to no excessive alternating stresses. The novel features of this cylinder design lie in the fact that the valve seats are entirely surrounded by water and that water space is provided above the combustion-chamber and below the top plate of the cylinder. The cylinder-head is therefore extremely rigid, resisting deflection and assuring the maximum integrity of valve seats. The valve ports are machined integrally with the cylinder-head and are not welded thereto as in the case of the Liberty-engine cylinder. The water-jacket is wrapped around the cylinder, thus requiring a single vertical welded seam.

The relative arrangement of the valve housing and water, inlet and exhaust passages is contrary to conventional practice. While there are four valves per cylinder, two inlet and two exhaust, they are arranged in pairs athwartship, rather than on a longitudinal axis as is usual. The reasons for this construction are, first, to secure a simple valve-mechanism with a single camshaft to operate all the valves of each bank of cylinders; second, because the valve-housing casting is considerably simplified by this arrangement and it is possible to siamese the inlet and exhaust ports, respectively, of adjacent cylinders, thus minimizing the number of separating walls required in the casting. The net result is

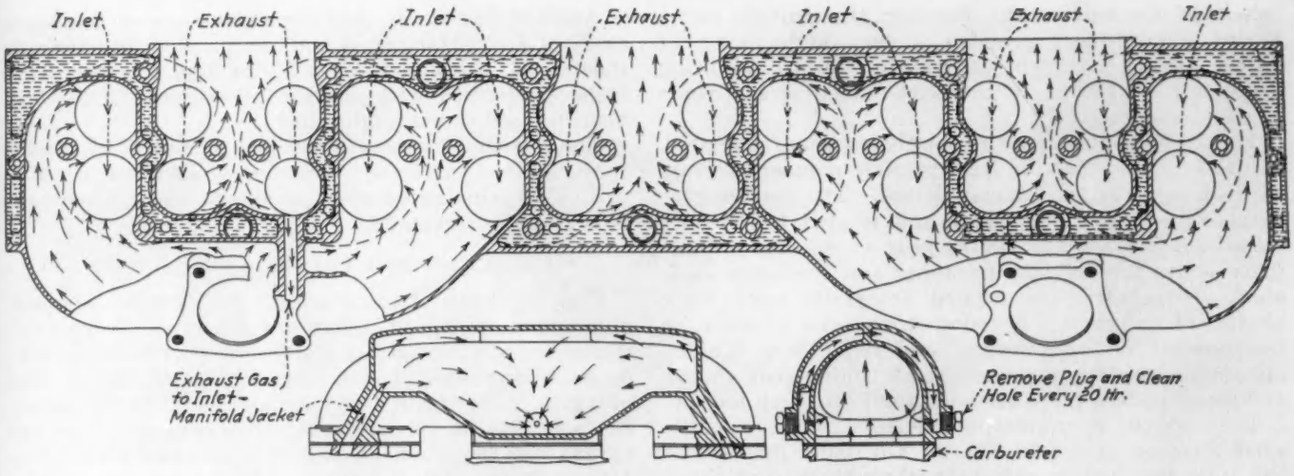


FIG. 5—CROSS-SECTION THROUGH VALVE-HOUSING PASSAGES
The Illustration Shows How a Controlled Circulation of Exhaust Gases Around the Intake Manifold Is Obtained

that ports of generous dimensions, combined with large valves, permit obtaining high volumetric efficiency at high speeds.

The arrangement whereby a controlled circulation of exhaust gases around the intake manifold is obtained is shown in Fig. 5. A short passage communicates between the exhaust port and a jacket surrounding the inlet manifold. In the latter, two small drilled plugs are provided which, under idling conditions, induce a considerable flow of exhaust gases around the intake manifold and into the mixture, thereby promoting good distribution under idling and under throttled operating-conditions. Under wide-open-throttle running, the circulation of exhaust gases is greatly retarded due to the low vacuum existing in the intake manifold, and the mixture is fed to the cylinders at reduced temperature, which is favorable to high power-output with minimum detonation.

DESIGN OF PISTONS AND OTHER PARTS

The piston design shown in Fig. 6 incorporates extremely short skirts, the over-all length of the pistons being 3.164 in. for a diameter of 5.375 in. These compact pistons materially assist in reducing the over-all height of the engine, and they have proved very satisfactory during several years of service operation.

Another unique feature of this engine is the valve-spring arrangement shown in Fig. 7, seven small piano-wire springs being arranged concentrically around the valve stem. These springs are guided by tubular guides welded to the lower valve-spring washer and, in the case of the exhaust-valve springs, these guides are inclined at an angle of 4 deg. to the vertical. This arrangement causes the valve to rotate during its operation, tending to preserve good surfaces on the seats of the valve and the cylinder and also to eliminate warpage, because the head of the valve is maintained at a uniform temperature in spite of the fact that the main discharge of the exhaust gases is confined to a portion of the per-

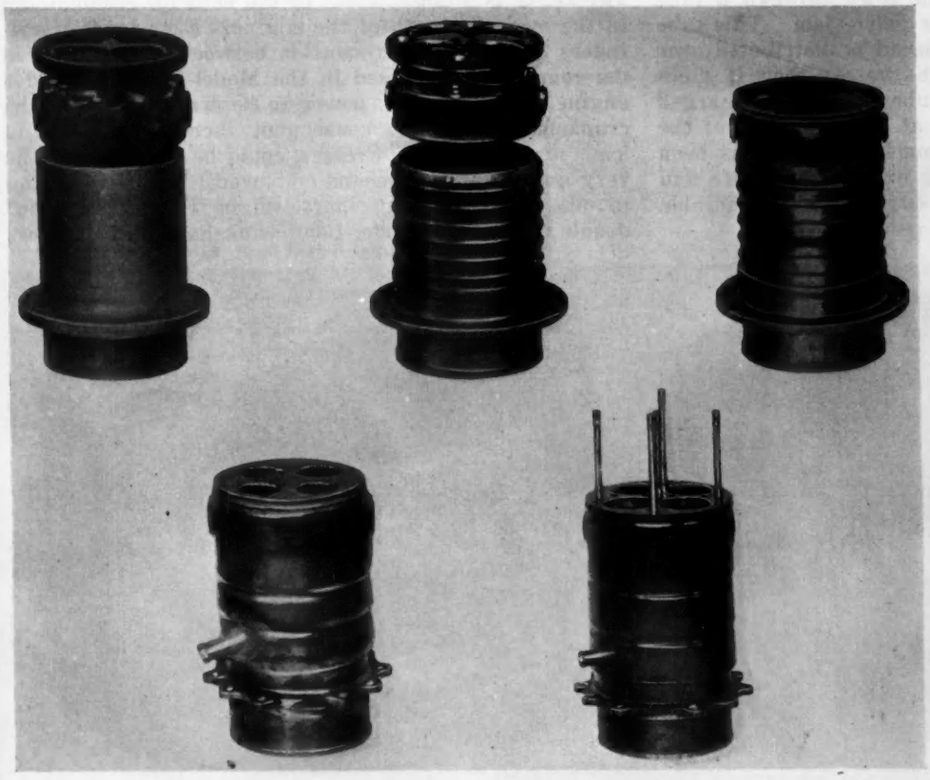


FIG. 4—CYLINDERS OF THE PACKARD X ENGINE
These Cylinders Are Built-Up from Steel Forgings Welded Together, with All Welds Arranged So As To Be Subjected to No Excessive Alternating Stresses

iphery of the valve seat. Further, the multiple valve-spring arrangement provides a very high factor of safety against complete valve-spring failure, assuring freedom from trouble of this sort during several years of flight service.

Fig. 8 shows the layout of the timing gears employed. It will be noted that the least possible number of gears is used to serve the various drives. The master gear is splined to the crankshaft and located by suitable thrust-surfaces in the timing-gear case. The center-drive gears for driving the upper and the lower camshaft driveshafts are formed integrally with their shafts. This practice is followed wherever possible, in the interest of light weight and reliability. Chilled aluminum bearings are used on all timing-gear shafts, and pressure-feed lubrication is supplied to each journal.

The method of circulating oil through the exhaust-valve stems is shown in Fig. 9. Oil under pressure is led into the hollow camshaft through a continuous groove in the rear camshaft-bearing. Suitable holes are provided in the camshaft to lubricate the bearings adjacent to the inlet and the exhaust-cam followers. In the case of the latter these holes register with passages in the camshaft bearings that allow the oil to flow into the closed-end cylinder in which the cam-follower stem operates. Registration is effected at the time that the exhaust valves are closed; consequently, the cam follower is raised to its highest position. As the camshaft turns it acts as a rotary valve to seal the oil occupying the space beneath the cam-follower stem; and, upon further rotation of the camshaft while the cam follower is depressed, the oil trapped in this space is forced to flow through holes provided in the cam follower, thence through the hollow tappets and down through a tube which is pressed into the hollow valve-stem. This tube is open at the lower end and the oil is distributed over the interior of the head of the valve; then it flows around the outside of the tube and is discharged through the two holes provided at the upper end of the valve stem. In these engines much attention has been paid to securing extremely long exhaust-valve life and the oil-cooling has proved to contribute a considerable share to the general excellent result.

Another feature is that the exhaust-valve seats are made of Delhi-Hard steel and are pressed into the cylinder-head, being spun over at the top, this operation being performed with the aid of a Ford front-wheel bearing used as a spinning tool.

The various features mentioned combine to render these engines particularly immune from valve troubles, and valve grinding between periods of general overhaul is practically unknown.

Crankcase and Crankshaft Features

Fig. 10 shows the crankcase. Its extreme ruggedness and simplicity of design are apparent. In general, it consists of a hexagon-shaped casting with seven large main-bearing shell bores formed in well-ribbed diaphragms. The main bearings are babbitt-lined steel-shells of 7¾-in. inside-diameter. These bearings are shrunk into the crankcase, which is previously heated to 212 deg. fahr. The bearings are supported on a water-cooled mandrel and slide easily into place, being then retained by cap screws. After the water-cooled mandrel is withdrawn and the crankcase cools to operating temperature, these bearings naturally are firmly held in place.

Although it is believed that the surface speed to which these bearings are subjected far exceeds previous practice in this regard, no trouble has been experienced with them in spite of the fact that the PV value amounts to about 53,000. The surface speed is about 5500 ft. per min., and the maximum load on the bearings is somewhat less than 700 lb. per sq. in.

The necessity for this type of crankshaft in which the crank cheeks perform the function of main journals, or vice versa, is brought about by the need for economizing in the over-all length of the engine. Each bank of cylinders has the same dimension between adjacent cylinder-centers as that used in the Model-1500 12-cylinder engine. Doubling the power to be transmitted by the crankshaft, with the consequent increase in bearing loads and crankshaft stresses, could be met only by the very unconventional means employed. It is interesting to note that this crankshaft weighs 161 lb., or about double that of the Model-1500 crankshaft which follows

Fig. 6—Packard X Engine Piston

The Design Incorporates Extremely Short Skirts, the Over-All Length of the Pistons Being 3.164 In. for a Diameter of 5.375 In.

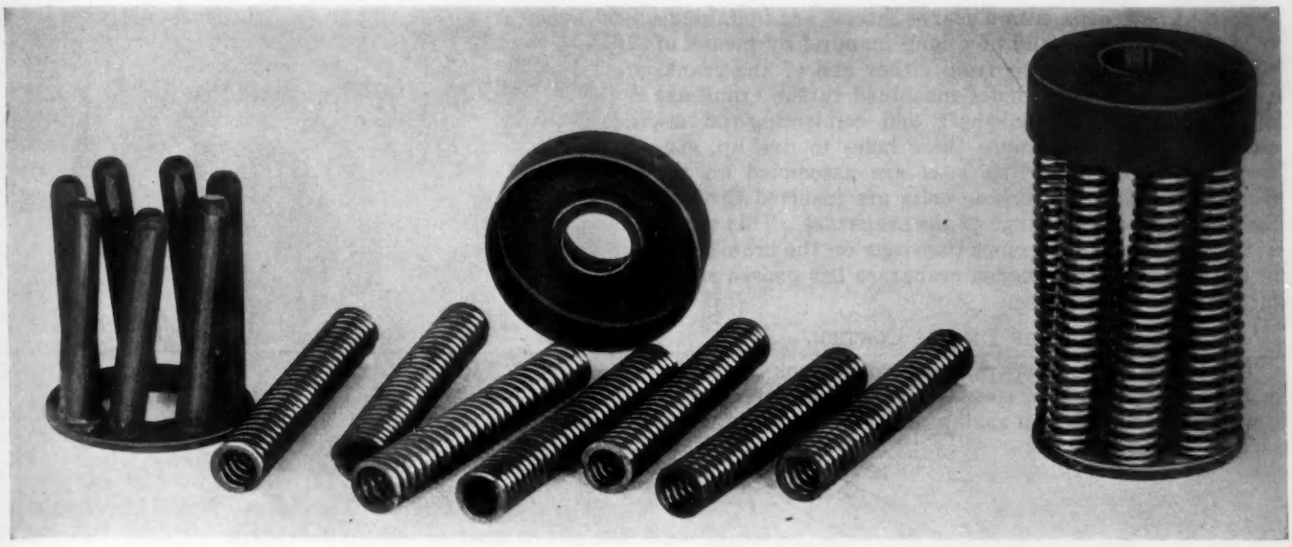


FIG. 7—PACKARD X ENGINE VALVE-SPRING ARRANGEMENT

Seven Small Piano-Wire Springs Are Arranged Concentrically Around the Valve Stems. These Springs Are Guided by Tubular Guides Welded to the Valve-Spring Washer. The Exhaust-Valve-Spring Guides Are Inclined at an Angle of 4 Deg. to the Vertical, Causing the Valve to Rotate During Its Operation

conventional design and transmits but one-half the torque that the X-type-engine crankshaft transmits.

To secure twelve equally spaced impulses per revolution a new arrangement of crank throws was necessary; therefore, No. 3 and No. 4 crankpins are displaced 30 deg. with respect to one another. Special balancing means were required with this arrangement of crank throws and the final result, measured in terms of the smoothness with which this engine operated, was very satisfactory.

OTHER MECHANICAL DETAILS

The endwise location of the crankshaft is maintained by the deep-groove ball-bearing mounted in the timing-gear housing and attached to a flanged shaft-extension at the rear end of the crankshaft. The propeller-shaft runs in a babbitt-lined steel-bearing mounted in the nose of the conical casting bolted to the front end of the crankcase, the rear end of the propeller-shaft being piloted in a bronze bushing pressed into the front end of the crankshaft. The propeller thrust is taken through a deep-groove ball-bearing mounted so as to exclude the possibility of its taking any radial load.

The drive connection between the propeller-shaft and the crankshaft consists of a spring coupling adapted not only to guard against any possibility of synchronization of torsional vibrations in the crankshaft and in the propeller-shaft and also to provide a convenient means for separating the propeller-shaft assembly from the crankshaft when dismantling the engine.

The connecting-rod assembly shown in Fig. 11 is of the articulated-rod construction, consisting of one master rod and three link-rods. The two sets of link rods for the lower banks are hinged in suitable bosses provided in the connecting-rod-bearing cap. The lower link-rods are 1½ in. longer than the upper rods to maintain the same maximum angularity in all four sets of connecting-rods. The rigidity of the connecting-rod assembly is enhanced by the use of two bolts and four studs connecting the two halves of the bearing, the two long bolts serving also to lock in position the three link-rod pins.

Regarding the method of assembling the connecting-rods on the crankshaft, after the crankshaft has been placed in position in the crankcase, the master connecting-rod with its cap is fastened in position on its crankpin by the four studs. The link-rod pins, which are

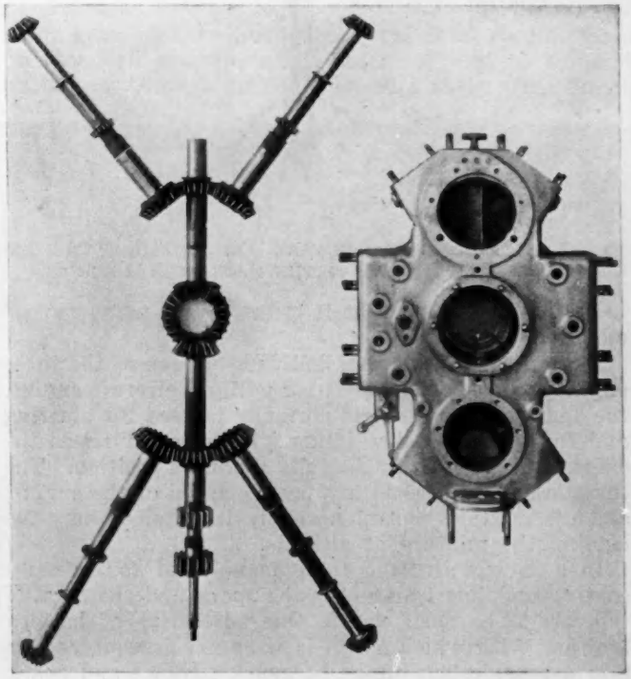


FIG. 8—LAYOUT OF PACKARD X ENGINE TIMING GEARS

The Least Possible Number of Gears Is Used to Serve the Various Drives. The Master Gear Is Splined to the Crankshaft, Being Located by Suitable Thrust-Surfaces in the Timing-Gear Case. The Center-Drive Gears for Driving the Upper and the Lower Camshaft Driveshafts Are Formed Integrally with Their Shafts

tapped at both ends with a coarse thread, are individually screwed onto the end of a long mandrel by means of which they are inserted from either end of the crankcase through suitable holes machined in the crankcase diaphragms. The crankshaft and connecting-rod assembly is rotated to cause these holes to line up, successively. After the link rods are assembled on the master rod, the long locking-bolts are inserted through the cylinder-bore openings of the crankcase. This method of assembling the connecting-rods on the crankshaft in a one-piece barrel-shaped crankcase has proved satisfactory in every respect.

Details of Engine Control

The diagram of the spark and throttle hook-up shown in Fig. 12 represents a special development intended to simplify the duties of a racing pilot, but the result has

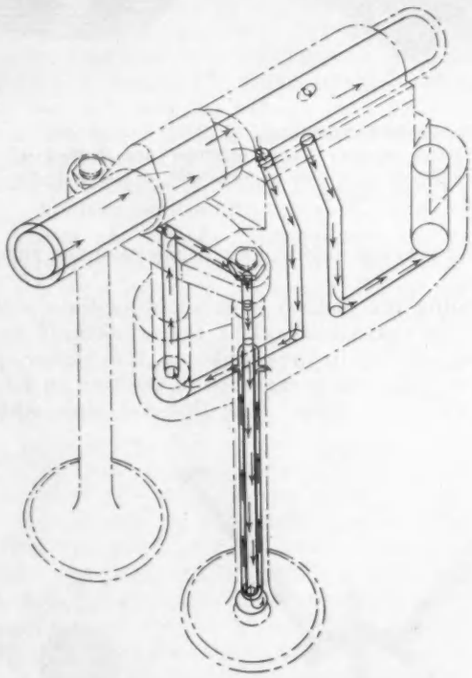


Fig. 9—Method of Circulating Oil Through the Exhaust-Valve Stems of the Packard X Engine

been so satisfactory that it is worthy of more general adoption.

Regarding the function and uses of each of the three engine-controls commonly used with an aircraft engine, the spark-advance control normally is used for starting and for especially slow idling. At all other times the spark control is left in the fully advanced position. The throttle control is used to vary the speed of the engine, and the mixture control normally is required only for leaning the mixture at altitude.

In a racing airplane there is no need for mixture control, and this leaves only the spark and the throttle controls to be dealt with. One advantage of battery ignition, with which the X-type engine is equipped, is that a considerable range of spark advance and spark retardation can be secured, which is not true of magneto ignition. This range proves to be of particular value in idling the engine down to very low speed while still maintaining sufficient velocity through the carbureters to eliminate the possibility of choking the engine. This very slow idling is highly desirable when landing a

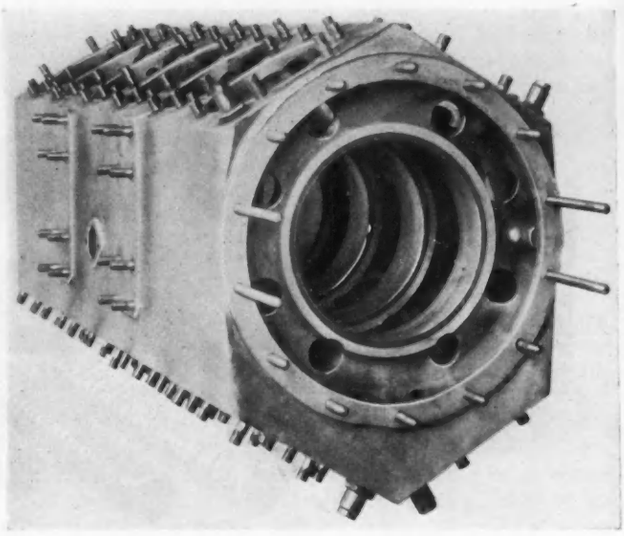


Fig. 10—Crankcase of the Packard X Engine

plane as, in this manner, "floating", or a tendency for the airplane to lose speed very slowly when coming in for a landing, is reduced to the minimum, and this aids the pilot to land in a limited area. However, the engine must at all times accelerate promptly, no matter how suddenly the throttle may be jerked open by the pilot.

Experience has shown that these various requirements for slow idling and good acceleration can best be met by manipulation of the spark and the throttle

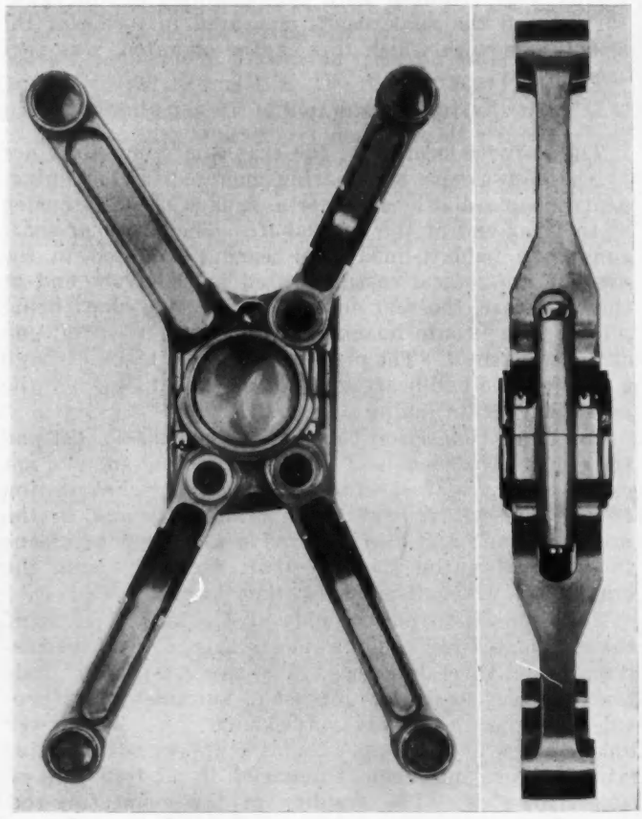


Fig. 11—Connecting-Rod Assembly of the Packard X Engine

controls simultaneously in accordance with some such curve as is shown in the left middle portion of Fig. 12. It will be observed that, for starting, the throttles are closed and the spark fully retarded. Once the engine is started, it is desirable to advance the spark somewhat before opening the throttles to prevent the engine from "spitting back." Further acceleration of the engine up to cruising speeds is obtained by operating both the spark and the throttle controls simultaneously so that, at cruising speed, the spark is fully advanced although the throttle is only partly open. From cruising speed to top speed, the engine speed is controlled solely by the carbureter throttles.

The method by which this desirable control is effected is clearly shown in the diagram. No cams or springs are employed in the hook-up, the result being achieved merely by locating the various levers on their shafts in the best location to suit the requirements. For example, the throttle connecting-rod practically passes over center when first opened, and a similar toggle action is secured with the spark-control rod as soon as the spark is fully advanced. This results in obtaining automatically the best response of the engine as the need arises, with only one engine-control lever for the pilot to manipulate.

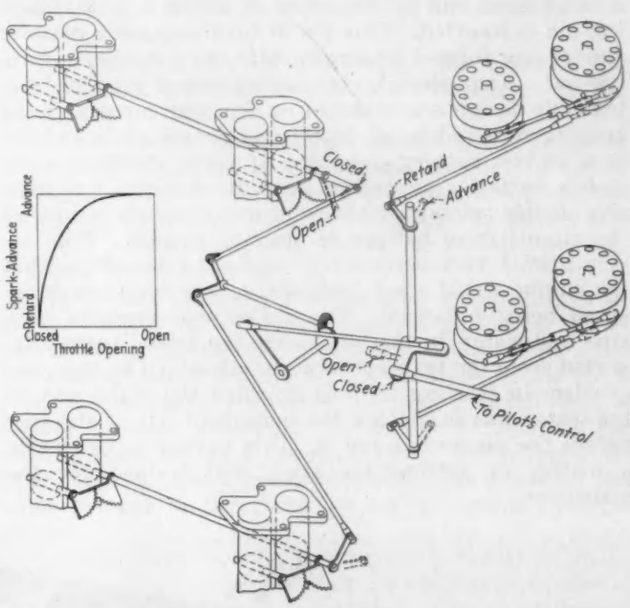


FIG. 12—SPARK AND THROTTLE HOOK-UP OF THE PACKARD X ENGINE

Experience Has Shown That the Various Requirements for Slow Idling and Good Acceleration Can Best be Met by Manipulation of the Spark and the Throttle Controls Simultaneously, in Accordance With Some Such Curve as Is Shown

EXPERIMENTAL AND ACCEPTANCE TESTS

The course of preparatory testing to which this engine was subjected before it was installed in the plane was very rigorous, because the life of a racing pilot depends more on whether his engine continues to function than on any one other thing, granting that the plane and propeller are structurally sound. The acceptance test was a 1-hr. non-stop full-power run on the dynamometer. Next, the engine was mounted on the stand shown in Fig. 13 with the propeller selected for the first flight, there being no testing equipment in the Country available to give this propeller a whirling test at the maximum number of revolutions per minute at which it must revolve in flight. The pitch of the blades was adjusted so that this whirling test could be made on the engine, and this was the first test conducted on the set-up shown. Following this, tests were made with the propeller blades set at various angles, and the data were plotted to check the characteristics of the propeller. In all this work Lieut. Alford J. Williams, Navy racing pilot, handled the engine so as to secure all possible advance operating-knowledge in connection with the engine.

Later, it was found that the regular clamping means used to prevent the propeller blades from rotating in the hub and thus altering the pitch were insufficient for this powerful engine, the blades creeping slightly during flight. This trouble was promptly overcome by lapping the blades into the hub so as to assure perfect contact on the whole surface.

Fig. 14 shows the struts for attaching the pontoons of the seaplane and the supporting struts of the engine. It illustrates how the absence of additional engine-supporting structure improves the general accessibility of the powerplant. The electric starting-equipment is shown also. The tripod is made of steel tubing; each leg is of telescopic construction so that the height can be adjusted. The tripod supports a box-like structure made of boiler plate, in the center of which a horizontal shaft is journaled in ball-bearings. The rear end of this shaft carries a standard automobile flywheel equipped with a hardened steel ring-gear, and the front end of the shaft terminates in a standard propeller-shaft universal-joint to which is attached, through splined fittings, a short shaft having

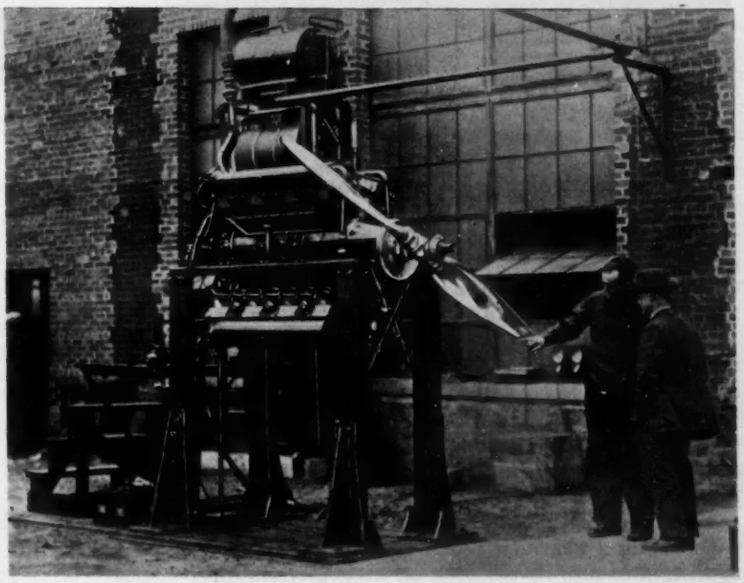


FIG. 13—TEST STAND DEVISED FOR TESTING THE PACKARD X ENGINE PREVIOUS TO ITS FIRST FLIGHT

The Test Was Made To Determine the Maximum Number of Revolutions Per Minute at Which the Propeller Must Revolve in Flight. Subsequently, Tests Were Made With the Propeller Blades Set at Various Angles and the Data Were Plotted to Check the Characteristics of the Propeller

a ball-headed end in the center of which a 5/8-in. starting-pin is inserted. This pin in turn engages a massive starter-dog formed integrally with the propeller retaining-nut. Four electric starting-motors of standard automobile design are mounted on the four corners of the housing referred to, all four being connected in parallel to a 24-volt battery composed of eight standard automobile batteries connected in multiple-series. A massive double-pole single-throw starting-switch completes the circuit from battery to starting motors. This device proved very satisfactory and gave assurance that the engine would start promptly, a very high cranking-speed being obtained. The device was used on both land and water, in the latter case the tripod being supported from the transom of a motorboat. The only real problem in starting the engine when the plane was on the water was in getting the motorboat out of the way before the plane over-ran it. This proved to be merely a matter of getting the crew well trained for the maneuver.

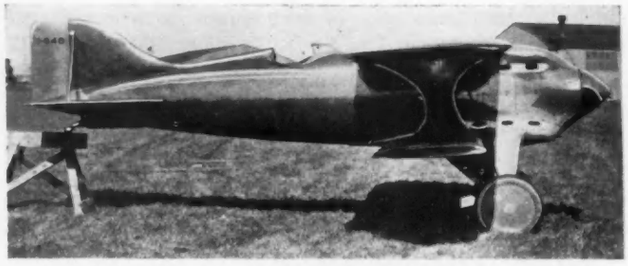


FIG. 15—PACKARD X ENGINE INSTALLED IN A RACING AIRPLANE

In connection with this project, Fig. 16 shows the increase in airplane speed for the last 22 years. Although these data were compiled a short time ago, they are already made obsolete by Bernardi's recent speed record of 318 m.p.h. There is no question that this curve will keep on rising, and I confidently expect to see a speed of 500 m.p.h. realized within the next 10 years. However, such results can be obtained only through the support of Government agencies, since not only is the expense involved in racing-plane development far beyond the resources of private capital, considering the returns to be obtained, but the Government alone possesses the needed skilled specialists and the elaborate testing-equipment required for this development work. As an example, I cite the full-scale wind-tunnel recently put into operation at Langley Field by the National Advisory Committee for Aeronautics. It will be of incalculable value in solving some of the little-understood problems of racing-airplane design.

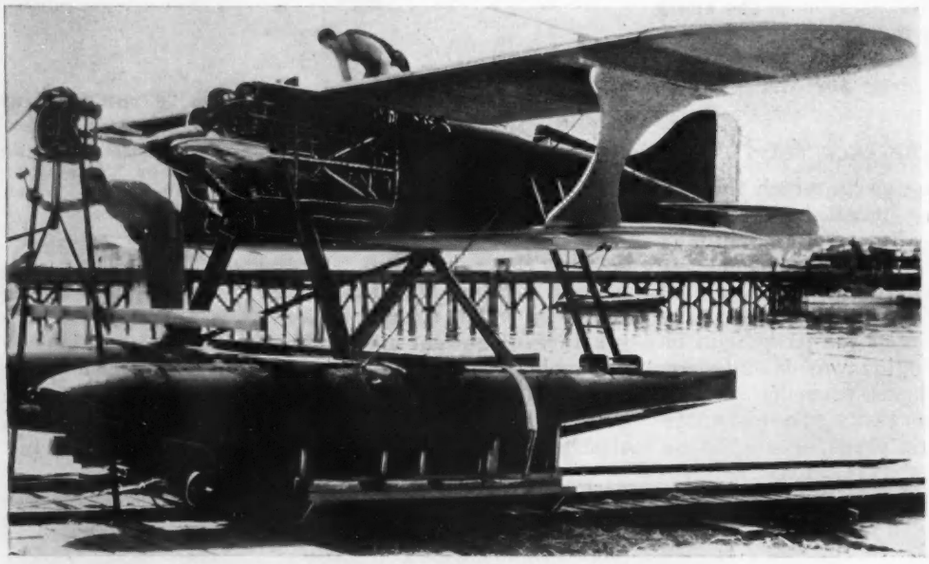


FIG. 14—SEAPLANE INSTALLATION OF THE PACKARD X ENGINE
The Struts for Attaching the Pontoons and the Supporting Struts of the Engine Are Evident

A considerable amount of flight testing was done with the plane equipped as a seaplane; and some valuable data were obtained in connection with the float design, which proved unsatisfactory at first due to a tendency to make the plane extremely nose-heavy at speeds in excess of 200 m.p.h. This phenomenon which, I believe, had never been experienced previously, was the direct cause of our being unable to get the plane over to Italy in time to participate in the Schneider Trophy race. Aerodynamic data to be obtained in no other way than by full-scale testing were acquired during this period and will prove of great value in the further development and refinement of this plane.

Following the seaplane tests, the plane was equipped with landing-gear as shown in Fig. 15 and the nose cowling was improved. As an airplane, the high-speed balance of the craft was found to be very satisfactory. Flight testing was continued until fall weather-conditions made a postponement necessary. Several high-speed tests were made and a maximum speed of 322 m.p.h. was recorded unofficially.

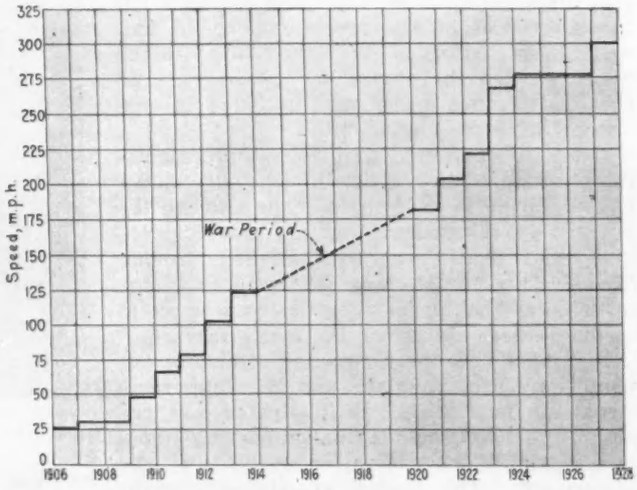


FIG. 16—INCREASE IN AIRPLANE SPEED FOR THE LAST 22 YEARS

THE DISCUSSION

PROF. C. F. TAYLOR[2]:—I was with the Army Air Service when the Packard Company started developing the type of engine of which this one is the latest example. This cylinder and valve-port construction was so different from anything that had been used before that there was some doubt in the minds of the Army Air Service personnel as to whether the Government ought to enter into contracts with the Packard Company for such an unknown quantity. However, there appeared to be good reasons behind all of the innovations, and they have since justified the thought and engineering ability expended in developing them. I cannot help complimenting Mr. Woolson, as I recall the doubt we felt at the time the first contract for this particular cylinder construction was placed.

Mr. Woolson did not bring with him the cooling-system that goes with his engine. I wish that he had brought it. It would weigh not less than 800 lb. and probably much more. I think about ½ lb. per engine horsepower is the least weight for a good water-cooling system. We will admit that, with wing-skin radiators, it is possible to reduce head resistance considerably, as compared with the air-cooled engine; but weight is also a very important factor, and this engine will, with its cooling-system, weigh at least 500 to 600 lb. more than the same engine would weigh if air cooled.

There is no doubt that this type of engine could be air cooled. Some increase in over-all dimensions would have to be made, but they would not be serious. By lengthening it about 6 in. and changing some of the valve and valve-gear arrangements, it is possible to air cool an engine like the Packard X. It will not be so very long before an air-cooled engine of a similar design will be available.

While the air-cooled X-type engine would involve the head resistance of the cowling necessary to allow the air to come in at the front of each V and pass between the cylinders, the total weight would certainly be less than that of the corresponding water-cooled engine. Except where high speed is of the utmost importance, as in racing, the air-cooled X-type engine would have the advantage over the water-cooled engine of the same size and type.

VARIED TYPES OF AIR-COOLED ENGINES

Air-cooled engines can be made in a wide variety of types. The air-cooled Liberty-engine is an example of the V type. It differs from the water-cooled Liberty-engine in several respects. First, it is slightly longer than a water-cooled engine of the same cylinder-bore, because there must be room for the air to pass between the cylinders. The valves are spread at a considerable angle to get plenty of air around the valve ports and the cylinder-head. In these respects, the air-cooled V-type engine is somewhat less compact than the water-cooled engine of corresponding type and size.

The A.D.C. "Cirrus" is a four-cylinder 75-hp. vertical air-cooled engine which is very popular in Engiand. Satisfactory cooling of all cylinders is accomplished by means of a small metal "scoop" on the exhaust side of the cylinders. Air flows into the opening at the front of this scoop; from there it must flow between the cylinders and out the other side of the engine to the atmosphere.

An illustration of the power-weight possibilities of the air-cooled engine is the Bristol Mercury, a radial developed for the last Schneider Cup Race from the Jupiter, with certain changes. It is said to deliver 800 hp. with a total weight of 680 lb., or 0.85 lb. per hp., complete with cooling system.

The Curtiss Company is developing a special type of engine, details of which will soon be published. It is essentially a 12-cylinder double-row radial; but, since the rear cylinders are directly behind those of the front row, the ordinary method of cooling a radial engine cannot be used. Instead, the engine is treated, for cooling purposes, as a group of three four-cylinder V-type engines. Each group is cowled and cooled in the same manner as described for the air-cooled Liberty-engine.

Perhaps these few illustrations will serve to dispel the popular misconception that air cooling is inseparably connected with the radial engine. The radial engine is particularly well adapted to it, because all the cylinders are in the same position relative to the airstream. The radial is also inherently lighter than most other types, but has the great disadvantage of considerable interference with vision when mounted at the front of a small fuselage.

I rather look forward to the development of the V-type and the X-type engines to displace the radial engine for military pursuit airplanes where good forward vision is essential. The development of air-cooled horizontal-opposed engines for use inside the wings of multi-engined airplanes also appears attractive.

MAXIMUM POWER OF ENGINES

R. ABELL[3]:—What bore and stroke has the X-type engine? What advantage, if any, has the bore and stroke used in the six-cylinder Gold-Cup engine? I think it has a shorter stroke than bore. What is the decrease in friction due to the decreased inertia-forces of an engine having a shorter stroke than bore; in other words, what is the advantage of cutting down the piston travel for a given displacement of engine? How does the displacement of this engine compare with that of the Gold-Cup engine?

L. M. WOOLSON:—The bore of the X-type engine is 5⅜ in. and the stroke is 5 in. The stroke of the Gold-Cup engine is 4 9/16 in. and it has the same bore as that of the X-type engine. Based on experience, I believe that the maximum power of a gasoline engine is determined almost entirely by its valving. Assuming that a certain size of inlet valve is used and that the carbureter and manifold sizes are correctly proportioned, then this valve will determine the power output of the cylinder. The speed at which the maximum power is obtained will be represented by a certain critical piston speed corresponding to a critical velocity through the inlet valve. The engine speed at which this piston speed is obtained will, of course, depend upon the stroke of the engine. If the stroke is long, maximum power will be secured at correspondingly low speed. If the stroke is short, then the power curve will peak at a higher speed but the maximum output in all

[2] M.S.A.E.—Associate professor, Massachusetts Institute of Technology, Cambridge, Mass.

[3] M.S.A.E.—General manager, Single Valve Engine Co., Mattapan, Mass.

cases will be substantially the same. For example, the Gold-Cup engine has a 5⅜-in. bore and a 4 9/16-in. stroke. Its peak output is obtained at about 3000 r.p.m. and our Model-1500 engine, using identically the same valving arrangement and having a 5⅜-in. bore and a 5½-in. stroke peaks at substantially 2500 r.p.m. In the case of the Gold-Cup engine, the reduced stroke is necessary to comply with racing rules which stipulate a maximum displacement of 625 cu. in. for the six cylinders. In fact, the short stroke worked out very nicely because it permitted a high wheel-speed which was necessary in this case to obtain the maximum propeller efficiency at the high speeds which the racing boats are capable of reaching.

Power Increase Due to Supercharging

JOHN F. DUBY[4]:—Were any changes in the engine itself necessary when the supercharger was fitted? How much additional power did the supercharger give to the engine?

MR. WOOLSON:—No changes were made in the basic engine except that the carbureters were of the supercharged type; that is, fitted with packing glands at the throttle bearings. The problem of correct carburetion with the carbureters on the pressure side of the supercharger is, however, difficult. When the carbureters are applied to the atmosphere side of the supercharger, no changes are required in the carbureters and this simplifies matters considerably. Concerning the additional power secured from the supercharger, I am not in position to give this information definitely, since we did not actually peak the supercharged engine, but I am convinced that the supercharger would add 300 hp. to the unsupercharged result.

CHAIRMAN F. E. H. JOHNSON[5]:—To take care of the increase in power due to a supercharger, if applied to the passenger automobile, would not this necessitate a change in the general design of the engine?

MR. WOOLSON:—Automobiles have a tremendous capacity for service, and the crankshafts are made extremely rigid to assure smooth operation. The average high-class 80-hp. automobile crankshaft could transmit 200 hp. easily. Everything concerning an automobile engine is designed for rigidity, to obtain freedom from vibration. Stress limitations do not enter into the question. In the engine I describe, we allowed for a fairly large factor of safety. The crankshaft, connecting-rods and other parts have a maximum stress of around 15,000 lb. per sq. in., and we feel that adding 25 per cent to that is not very serious. We have not reached the limit of bearing loads.

C. C. LAWTON[6]:—I understand that the gasoline consumption per developed horsepower is greater with the supercharger than without it. If so, is it economical to install a supercharger?

MR. WOOLSON:—It is true that a supercharged engine is less economical of fuel than is a non-supercharged engine. The choice depends altogether upon the service required. For a long-range airplane the supercharged engine should not be used, but the supercharged engine is distinctly required for racing purposes or to obtain an altitude record, since the proportionately small amount of additional fuel needed in these last two cases is of little consequence. There is an intermediate possibility in the supercharger as used on the Mercedes cars, in which the supercharger is clutched into engagement only at such times as maximum output is desired.

Supercharger Noise an Objection

CHAIRMAN JOHNSON:—Is not noise the chief reason superchargers are not used on cars sold to the public today?

MR. WOOLSON:—Yes.

DR. S. A. MOSS[7]:—Regarding noise, the centrifugal type of supercharger, when built into the engine, makes no noise that can be heard outside; furthermore, it is highly efficient. Such a supercharger permits passage of gasoline through it, which improves distribution and makes starting easier. In engines with centrifugal-type superchargers, there is no increase in fuel consumption and, in some cases, there has been a decrease; that is, the fuel per horsepower-hour is reduced. Centrifugal superchargers are used in practically all the radial air-cooled engines and in some of the Packard water-cooled engines. Will Mr. Woolson compare the performance of the Packard engine with the centrifugal supercharger and with the Roots-type supercharger?

MR. WOOLSON:—Dr. Moss calls these centrifugal blowers on radial engines "superchargers," but they are not superchargers. I believe the proper phrase for them is rotary induction-systems. To the best of my belief, the centrifugal blowers used in these radial engines just about offset the pressure drop through the induction system of the radial engine. However, in performing the function of a rotary distributor it aids distribution to a considerable degree and, in this way, the comparatively small amount of power required to drive the impeller at the relatively low speed used is well repaid. As to the relative values of Roots-type and centrifugal superchargers, we have used both types and appreciate the good points of the centrifugal design. However, there was no place on this particular engine to locate the centrifugal type, and the Roots type worked in very well where it added no frontal area.

J. POPE[8]:—All airplane engines are in the last analysis air-cooled engines, the difference being that, in one type, the air is applied directly to the hot surfaces of the egine and, in the other type, water is used as an intermediary to transfer the heat of the engine to the atmosphere. What are the particular advantages of using this latter indirect system?

What is the relative vulnerability of a water-cooled-engine plane as compared with an air-cooled-engine plane? It seems to me that a radiator system of the wing-skin type presents a large target. If punctured by a shot would not the engine immediately get into difficulty because of loss of water?

MR. WOOLSON:—Water-cooled engines can be made very much more compact because space does not have to be provided for air to flow between cylinders. The inverted Liberty air-cooled engine had cylinder centers of 6½ in., and yet it was necessary to reduce the bore to 4¾ in. from the 5-in. dimension used in the water-cooled Liberty. With only 6-in. cylinder-centers on our engines we are able to use 5⅜-in. bore; hence, if we substituted air-cooled cylinders, we would have to

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[6] A.S.A.E.—Service manager, Worcester Buick Co., Worcester, Mass.

[7] Thomson Research Laboratory, General Electric Co., Lynn, Mass.

[8] Consulting engineer, Stone & Webster, Inc., Boston.

change from a 5⅜-in. bore to about 4¼ in., which represents a loss of nearly 40 per cent in displacement.

So far as vulnerability is concerned, there is no question that the wing-skin radiator presents a large target. However, all uptodate pursuit airplanes use a tunnel-type radiator which is of comparatively small area. The possibility that is receiving serious attention at present is the use of a wing-skin radiator employing steam cooling and, with this construction, a few bullet holes would not be of as much consequence as in the case of the water-cooled system.

Bearing Pressures and Lubrication

M. R. Wolfard[9]:—Regarding the bearing pressures that you carried, do you think you were able to do that by improving the surfaces? Was it merely a question of increased lubrication; or was it a question of using the same amount of lubrication as used today? In the latter case, could the pressures be increased safely?

Mr. Woolson:—Lubrication must be adequate. A complete series of experiments, made a number of years ago, indicated that the main thing about carrying high pressures is to have a bearing rigid enough not to deflect appreciably under load. Those engines in which the babbitt cracks under heavy load are always engines in which the bearing is not rigidly anchored or supported; babbitt has very poor physical properties, and yet it is an ideal bearing material. Provided that the bearing is adequately supported and well lubricated, extremely high bearing-loads and speeds can be reached.

Professor Taylor:—The latest developments in the theory of lubrication indicate that the higher the speed of the bearing is, the better the conditions of lubrication are. The old theory that the load is limited by the factor, load multiplied by speed, is entirely unsound. The main reason that airplane-engine bearings will withstand high loads is that they are run at sufficiently high speeds to keep an adequate film of lubricating oil between the surfaces.

Question:—What is the relation of the pressure carried in the oiling system to the speed of the bearing?

Mr. Woolson:—It is merely a matter of determining what oil pressure is necessary to secure the desired rate of oil circulation which, in turn, depends upon the increase in oil temperature to be specified. For example, in the X-type engine, we require an oil pressure of only 5 lb. per sq. in. to give an adequate supply for the main bearings, although we use a pressure of about 75 lb. per sq. in. on the connecting-rod bearings. Generally, for airplane and automobile engines, the amount of oil feed is controlled by the so-called "metering" system in which relatively high pressures are carried to the main bearings, but the groove in the bearing merely represents a sector of about 60 deg. in span so that the oil-feed hole in the crankshaft journal registers during only one-sixth of the time. This means that the pressure necessary is several times that which would suffice if the oil groove were continuous around the bearing. Hence, oil pressures by themselves mean nothing.

E. G. Kingston[10]:—How much of the power of the engine is used to drive the supercharger?

Mr. Woolson:—About 60 hp. at 2000 r.p.m.

Chairman Johnson:—That seems like a reasonable power absorption, because the gain is 300 hp., and there is only the additional weight against it.

In regard to the possibility of fitting the X-type engine in the wing section, if it could be laid on its side it might be possible to adapt it to a small wing-section; that is, one with only a reasonable amount of depth. Would it be feasible to run the engine on its side, with minor changes to take care of the change of position?

Mr. Woolson:—That suggestion has been made and is one well worth considering. In that connection, an important advantage would be that the exhaust pipes could go straight through the upper and lower surfaces of the wings.

Valves and Valve Action

V. A. Nielsen[11]:—When several valve springs are used, what pressure do they produce on the valve? How much impact does such a valve have against the seat at the time of closing? It was stated that the valve rotates, so I ask what rotation would there be of the valve with relation to the seat, or does the valve not actually rotate against the seat?

Mr. Woolson:—The load on the valve springs is about 40 lb. when the valves are seated and about 80 lb. when the valves are open. This gives more build-up of spring pressure than is customary, although there appears to be no objection to this procedure. With reference to the impact or deceleration immediately previous to the valve seating, we consider the maximum value is represented by a figure of 3000 ft. per sec. per sec. The rotation of the exhaust valve under the influence of the spirally arranged springs is very moderate, and I judge the valve makes one revolution in about 20 cycles.

W. B. Benedick[12]:—What is the advantage of alternating the opening of certain of the exhaust valves on the dual-valve system?

Mr. Woolson:—I assume that the question refers to opening first one valve in one cycle, the other valve in the next cycle, and so on. I cannot see the object of this construction and it certainly has no merits insofar as the inlet valves are concerned. In the case of the exhaust valves, there would of course be some additional cooling due to the greater percentage of time each valve was on its seat; but, on the other hand, there would be considerably more heat input to each valve while it was open, due to its comparatively restricted area.

Chairman Johnson:—With the oil-cooled valves, is there any tendency to form carbon?

Mr. Woolson:—No. It is merely a matter of maintaining sufficiently rapid circulation so that the oil comes out of the valve at a temperature of not more than 300 deg. fahr.

Chairman Johnson:—Did not the Packard Company develop special apparatus for studying the valve action?

Mr. Woolson:—Yes. The company uses a special type of stroboscope.

Chairman Johnson:—What is the oil consumption of the X-type engine at maximum speed?

Mr. Woolson:—At maximum power it is 0.045 lb. per b.hp-hr. At cruising speed, it is very much lower; 0.02 lb. per b.hp-hr.

Chairman Johnson:—Are special oil-rings used on the pistons?

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[10] A.S.A.E.—Owner and manager, John P. Kingston & Son, Worcester, Mass.

[11] M.S.A.E.—Treasurer, V. A. Nielsen Co., Boston.

[12] Service department, Noyes Buick Co., Boston.

MR. WOOLSON:—There are three rings on each piston, each 3/32 in. wide, and the lower one has a 3-deg. taper.

COMPRESSION RATIO AND ALTITUDE EFFECTS

QUESTION:—Which can carry the higher compression without detonation, the water-cooled or the air-cooled engine?

PROFESSOR TAYLOR:—With the same cylinder design, undoubtedly the higher compression could be used in the water-cooled type. The main argument for air cooling does not lie in the saving of weight so much as in the elimination of the troubles which always accompany the use of radiators, piping, and pumps. The elimination of all this equipment has established air cooling, for commercial work, more than has any other factor. For military work, the question between the two systems is perhaps an open one.

L. F. DANKER[13]:—What effect, if any, do different altitudes have on the operation of an air-cooled engine?

PROFESSOR TAYLOR:—An engine can have a very wide range of cylinder-wall temperature without affecting its operation to a very great extent, beyond a slight change in the piston friction, which incresaes with decreasing wall-temperature. However, some method of shutting off the air supply to keep the engine warm while idling would be desirable, especially at the low temperatures encountered at great altitudes.

[13] Treasurer, Danker & Donohue, Inc., Boston.

Modern Dowsers, or Divining Rods

NEW means of ore and oil prospecting have attracted the attention of many forward-looking financiers. The best known of the new methods is probably the Eötvös torsion-balance. This delicate instrument indicates minute variations in the gravitational pull of the earth due to the presence below the surface of materials that are of lower or higher specific gravity than the rocks usually present. Due to its extreme sensitiveness, great care is necessary in its operation, and the fact that only four measurements can be made per 24-hr. day seriously limits its usefulness. Irregularities in the surrounding topography necessitate corrections in the result, and the ground within a radius of 6 ft. must be carefully leveled. This instrument has been most useful in locating oil in the region of the Texas salt domes, and has had a limited success in the field of heavy minerals.

Two other methods of ore prospecting which deserve mention are the seismic or acoustic method and the magnetic method. The former depends upon the distortion or change in the velocity of a sound wave, or of an artificial earthquake-wave produced by an explosion. Detection of ore bodies by this method is complicated by fracture zones, faults, or folds in the rock structure, which usually produce greater distortion in the seismic wave than the ore itself. The magnetic method makes use of the pocket dip-needle and furnishes a rapid and cheap method of surveying areas showing pronounced magnetic characteristics. This is the oldest and most familiar application of physics to mining exploration.

ELECTRICAL PROSPECTING

The electrical methods can be divided into three classes: the self-potential, the surface potential, and the inductive—all of which depend upon the fact that beds of certain kinds of ore have different electrical properties from those of the surrounding rock. In the self-potential method the effect of oxidation at a part near the surface of a bed of sulphide ores establishes a current like that of a dry-cell.

The second electrical method is similar to the self-potential method except that the current is artificially produced by a battery or electric generator. If the ground is of uniform composition, the current will flow through the ground in parallel lines. If an ore bed happens to be between the two points, there occurs irregularity in the shape of the equi-potential lines, from which the position of the ore body is determined.

INDUCTIVE METHOD

In the inductive method an alternating magnetic field is created, which is similar to the natural magnetic field of the earth except for the fact that it reverses periodically at a high frequency. The magnetic field penetrates the rocks and soils of the earth nearly as readily as it does the air above. When a conductor such as an ore body is encountered, a new magnetic field of the same frequency and general characteristics is emitted by the conductor. This new field, called the secondary or induced magnetic field, radiates from the conductor in all directions in the same general manner as did the original one from the original source. This secondary field is the one to be studied, and from a measurement of the total of the primary and secondary fields the amount due to the ore is determined by subtracting that due to the known primary field. This method appears to have certain advantages over the other two electrical methods, although the electrical knowledge required and complications met in calculating the primary field make it impracticable except for highly skilled operators.

All of the above methods have certain limitations: they are not applicable to all types of ore, and the results of such prospecting cannot be considered absolute. In general, if no ore is indicated by these methods there is none present, but, unfortunately, the converse of the above is not always true. Combinations of several of these methods, however, properly interpreted by competent geologists, furnish fair evidence of the existence of ore deposits.—Industrial Bulletin of Arthur D. Little.

European Roads and American Cars

By TORE FRANZEN[1]

SEMI-ANNUAL MEETING PAPER

FINDINGS resulting from a first-hand study of car-suspension problems as presented by continental European road conditions, with particular reference to such complaints as "weak springs" and "striking through," as they relate to American cars, reveal two general types of European road and two types of motorist.

The sportsman who drives his own car at high speed over the old stone roads, now rough and poorly maintained, cares little for a smooth ride but complains of "striking through" of the frame on the axle. The larger class of owners, who want to ride in comfort and whose cars are driven by chauffeurs, frequently use very low tire-pressure and consequently shimmying often results.

Owing to a strong demand for quietness in the better cars, over-oiling of the springs and shock-absorbers is rather general and striking through occurs. Stiffer springs are the obvious preventive in this case. For the other type of service demanded, it should be fairly simple to develop a special suspension that need deviate little from present American spring practice, but particular attention should be paid to making shock-absorbers fool-proof, quiet and effective.

THIS paper deals with road conditions as they exist in Europe and the relation between these conditions and the designing of the suspension for cars to be exported to Europe.

Complaints of spring failures and especially of "striking through," received by some of our customers who export the larger and more luxurious automobiles, were the direct cause of the investigation of the conditions mentioned. The trip was limited to three months and this survey is, therefore, not complete. It included Holland, Belgium, France, Germany, Austria, Hungary, Jugo-Slavia, Czechoslovakia, Sweden and Switzerland.

It does not require a great deal of research to find that the cause of the European motorist's troubles are not springs, but roads. For this reason, a study of road conditions must, of necessity, be made before any remedies can be suggested.

To the European who came to America 15 or 20 years ago, the automobile roads of this Country did not look very good; in fact they did not at all compare with the solid roads of the Old World. It was then a rough task to drive 100 miles in a day on our established highways. To drive to Toledo from Detroit in 3 hr. under adverse weather conditions was a feat of heroic proportions, even in one of the Country's most powerful cars. But now the picture is reversed. The main roads of Continental Europe, once the trade routes of the civilized world, have deteriorated. The World War and lack of funds for road maintenance are factors contributing to their relatively poor condition. One can say without exaggeration that they look like mere trails in comparison with the familiar hard-surfaced roads of America.

It is not a startling statement to say that there are some bad roads and detours in this Country. The motorist is satisfied to ride over them at relatively low speeds because he knows that his difficulties are only temporary and soon he will be speeding over the smooth cement ribbons that form a veritable web over the entire Country. At best, Europe could not approach this condition, because of such important factors as geographic conditions and the indifferent attitude of the many nations toward progress and the importance of good roads. The roads of the British Isles and of Switzerland do not enter this discussion, as they compare more than favorably with those of America.

PEASANT SYSTEM OF ROAD MAINTENANCE

I would not have you think that Europeans are not interested in better roads, but do want to emphasize that road maintenance, in most cases, is not organized on nearly so sound a basis as it is in practically all parts of the United States. To illustrate: In most sections of Continental Europe the peasant whose property lies along the highway is responsible for the maintenance of that particular stretch of road. It is not at all an uncommon sight to see a peasant beside the road pounding away on a small rock-pile to get enough crushed stone to fill up ruts in front of his property. With the different peasants holding different views as to what constitutes a well-maintained road, one can readily see what a variety of road conditions can be encountered in a few miles of travel.

In certain parts of Europe the automobile is the direct cause of the expenditure of millions of dollars for new roads, and the road conditions there will soon approximate ours. We are not concerned with this at present, as the solution of American car-suspension problems will automatically solve similar problems in these sections; but the American automobile engineer is vitally interested in obtaining a relatively good ride over the roads just discussed.

TYPES OF EUROPEAN ROAD AND MOTORIST

These roads could perhaps be divided roughly into two types: the old stone roads and the dirt roads. The stone roads, which in many cases date back to the time of the Romans, while remarkable for their durability, are not very suitable for automobiles because they are extremely rough, relatively narrow, highly crowned, and the surfacing is mostly cobblestones or stone slabs. The dirt roads are like the soil around them, mostly deeply rutted and extremely rough when dry or frozen. Still, these are the roads over which the European has to travel, and he does not want to crawl along.

It is common knowledge that only relatively wealthy Europeans buy American cars selling here for $1,000 or more. These motorists can be divided roughly into two classes: First, there is the sportsman who drives

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his own car and gets a great deal of pleasure from speeding over poor roads. A good ride is of secondary importance to him, provided the car stands up and does not strike through. Extremely stiff springs are the solution. The number of such motorists is rather limited and their troubles need not detain us. Our concern is with the second type of motorist, who wants to travel in comfort and safety and whose car is invariably chauffeur-driven. Such owners frequently use very low tire-pressure to avoid annoying vibrations resulting from choppy roads. Actually, the results are not so gratifying as might be supposed, because low tire-pressure is accompanied by relatively high spring-deflection, and severe jolts are experienced when deep ruts in the road are encountered. Naturally, greater disturbances occur in the steering-gear, and shimmy often results. This condition is rather common. It is, therefore, obvious why scientific research on automobile suspension in Europe seems to be concentrated on correcting shimmying rather than improving riding comfort.

Over-Oiling Results in "Striking Through"

The demand for quietness in the more expensive automobiles is very strong. Consequently, slight noises in the running-gear, squeaks in springs, and grunts in shock-absorbers are quickly detected and the owners immediately make serious complaints. Thin oil is regarded as a universal remedy for such annoyances. With over-lubricated springs and the conventional drum-type of friction shock-absorber filled with oil, striking through is the result. Complaint is then made that the springs are weak. In one of Berlin's finest garages a special oil-gun is used for lubricating the shock-absorbers. This gun, in itself, is an efficient tool, but is actually a trouble-maker, as its use renders most of our conventional drum-type friction shock-absorbers virtually useless. The riding-quality that is one of the valuable sales assets which the American product has over the European automobile should not be jeopardized merely to prevent striking through. A drastic change in the present spring suspension is not to be considered, as it would, in all probability, destroy our enviable reputation for comfortable automobiles. Nevertheless, some important things have been learned which will be of assistance in designing suspensions for export cars.

Shock-Absorbers Need Special Attention

In our highly specialized automobile factories here, or in the depot shops of our plants in Europe, it would, perhaps, be relatively simple to develop a special suspension for use in sections of Europe where the car population is large enough to warrant it. Such suspensions would deviate but little from ours, so far as springs are concerned, but particular attention would have to be paid to shock-absorbers. They must be foolproof, quiet and effective. Striking through, which is one of the main objections raised against our finer automobiles, must be made milder without destroying the present good ride. Development in this field looks very encouraging and, with the proper service force, a car that affords a ride suiting each territory and the fancy of the car owners eventually can be worked out.

Airplane Designation Marks

TO the ordinary observer the lettering and figures printed on the wings and fuselage of an airplane are a deep mystery, but to those who have been associated with the aircraft industry for a long time these signs are like the signatures of well-known artists. They reveal to the initiated the type and builder of the plane, the purpose for which it is built, the type of engine, perhaps the number of the crew, and other more or less pertinent information.

The Navy's recently revised code-book gives code translations on all Naval aircraft and carries the following general classification. A little study of these will clear up a great deal of the mystery. Naval models of airplanes are divided into eight classes in accordance with the function to be performed. Each class is designated as follows:

Class	Designation
Fighting	VF
Transportation or general utility	VJ
Marine expeditionary	VM
Training	VN
Observation	VO
Patrol	VP
Scouting	VS
Torpedo and bombing	VT

The letter V indicates heavier-than-air. The letter Z would mean lighter-than-air.

If the plane is on duty with the Aircraft Squadrons, Scouting Fleet, the letter S usually follows, such as VF-5S, meaning Fighting Plane, Squadron Five, Scouting Fleet, while, if the ship is in the Aircraft Squadrons, Battle Fleet, the letter B is added.

The designation of airplanes of an experimental design is prefixed by the letter X. When the new plane is accepted for service and put into production, the prefix is dropped.

Each manufacturer has a designation letter. To date they are as follows:

A—Atlantic Aircraft Corporation (Fokker)
B—Boeing Airplane Co.
C—Curtiss Aeroplane & Motor Co.
D—Douglas Co.
E—G. Elias & Bros.
G—Eberhart Airplane & Motor Co.
H—Charles Ward Hall, Inc.
K—Keystone Airplane Co.
L—Loening Aeronautical Engineering Corporation
M—Glenn L. Martin Co.
N—Navy Department (Naval Aircraft Factory)
Q—Fairchild Aircraft Mfg. Corporation
R—Ford Motor Co.
U—Chance Vought Corporation
W—Wright Aeronautical Corporation
X—Cox-Klemin Airplane Corporation
Y—Consolidated Airplane Corporation

Tractor biplane bears the designation TB; tractor monoplane, TM; pusher biplane, PB; convertible, Conv't; landplane, Land; amphibian, Amphib; air-cooled engine (a) and water-cooled engine (W).

Commercial and air-mail planes all carry a number and letter combination which is, in effect, merely a license-plate for the plane. This number is assigned by the Department of Commerce on granting a certificate of air worthiness to a plane, and it is then painted on both top and bottom of the wings and on both sides of the tail, so that it can be read from any angle.—*Wright Engine Builder.*

The Angular Distortion of Crankshafts

By C. A. Norman[1] and K. W. Stinson[2]

Semi-Annual Meeting Paper — *Illustrated with* Photographs and Charts

REFERENCES are given to many articles and books on crankshaft vibration, written in both English and German. As published experimental data on deflections are lacking, the authors obtained an engine with four crankshafts, having crank-arms with different cross-sections, and measured the deflections under static load.

Deflections in various parts of the shafts are analyzed and compared, and a formula is developed for the deflection in the long crank-arms of the shaft.

THE nature of the torsional vibration of crankshafts is understood very well now by scientific engineers. A wealth of literature exists on the subject. In America Frank M. Lewis[3] has developed a method, now well known, for computing the speed of vibration. Experimental work on the subject has been published by J. H. Hunt and G. B. Embshoff[4], by Arnold Lack and C. B. Jahnke[5], and undoubtedly by others also. In Germany, books have been written thereon by Heinrich Holzer[6] and Hans Wydler[7]. An excellent treatment of the subject has been given by Max Tolle[8]; and simplified formulas have been published by J. Geiger[9], whose work also contains much material on experimental apparatus for the investigation of oscillations. A good little book in English on vibrations is by Julius Frith and Frederick Buckingham[10], but it does not deal very fully with torsional vibrations. Prof. S. P. Timoshenko deals with these, covering even the general case, although very succintly, in a book written in collaboration with J. M. Lessels[11]. Undoubtedly there are treatments in numerous other books.

Angular Distortion Information Is Meager

In the presence of such a wealth of information it is surprising to find that knowledge on the subject, at least published knowledge, seems to be uncertain as to one of the most fundamental factors entering the problem of the torsional vibration of crankshafts, a factor without which the natural period of the shaft cannot be computed. This factor is the angular distortion under given torques. In a recent American book on engine and crankshaft design, the assumption seems to be made that the angular distortion equals that of a straight shaft of a diameter equal to the journal diameters of the crankshaft, an assumption that is admitted to be of very uncertain validity. Professor Timoshenko has investigated the problem theoretically, but the formulas presented in his book, to which reference has been made, are rather formidable even when derived under simplifying assumptions. In a case of such complexity the

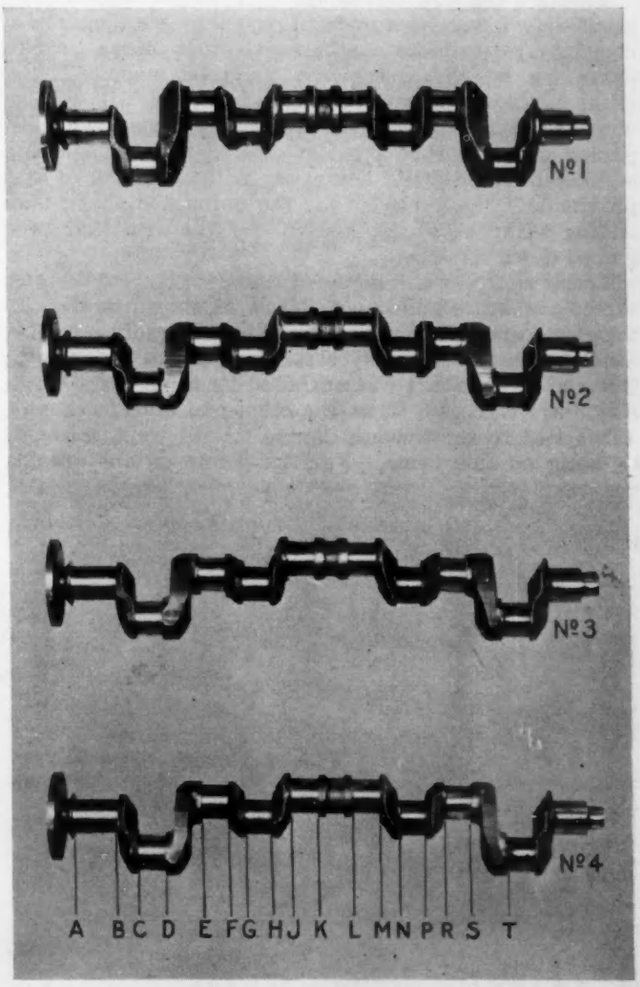

Fig. 1—Crankshafts for Deflection Tests

All Four Crankshafts Are for One Engine. No. 1 Has Its Crank-Arms in Their Original State. The Long Crank-Arms in Nos. 2, 3 and 4 Have Been Machined Down to Smaller Dimensions. Punch Marks Were Made at the Points Designated by the Letters

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[2] M.S.A.E.—Assistant professor in charge of automotive engineering, Ohio State University, Columbus, Ohio.

[3] See *The Journal of the American Society of Naval Engineers*, November, 1919, p. 857.

[4] See The Journal, April, 1925, p. 444.

[5] See *Transactions of American Society of Mechanical Engineers*, 1925, p. 493.

[6] See Die Berechnung der Drehschwingungen, Springer, Berlin, 1921.

[7] See Drehschwingungen in Kolbenmaschinenanlager, Springer, Berlin, 1922.

[8] See Der Kraftmaschinen Regelung, Third edition, Springer, Berlin, 1921.

[9] See Mechanische Schwingungen, Springer, Berlin, 1927.

[10] See Vibration in Engineering, Macdonald and Evans, London, 1924.

[11] See Applied Elasticity, Westinghouse Technical Night School Press, East Pittsburgh, Pa., 1925.

formulas certainly should be checked experimentally. Of published experimental investigations of this character there seems to be great dearth.

Dr. Friedrich Sass published in a German journal[12] such an investigation, undertaken on a large Diesel-engine crankshaft. He found his results much at variance with those obtained by most formulas available in literature. The best agreement, he says, was with the formula of Dr. I. Seelmann[13] which, fortunately, is not very complicated; but, since this formula is only semi-rational at best, it requires further experimental justification at least. The crankshaft of Dr. Sass had only straight radial crank-arms running from a main journal to the nearest pin. In automotive practice the crank-arms often run from one crankpin to another. In six-cylinder engines, moreover, such a crank-arm makes an angle of 30 deg. with the radii of the two cranks. We know of no experimental determination of the distortion of such arms.

Apparatus and Method

Through the kindness of the Continental Motors Corporation, we were fortunate in securing as a donation a complete six-cylinder engine with four extra crankshafts on which experiments could be made. These crankshafts are shown numbered in Fig. 1. It will be observed that the long arms on three of them have been planed down so that a series of dimensions has been secured in these arms, beginning with a section of approximately 3⅝ x 1⅞ in. for the untouched shaft, and ending with one of 2½ x 1 in. for the arm that was planed down the most.

These shafts were mounted successively in the inverted crankcase and engine block, as shown in Fig. 2, the crankcase and block being fastened rigidly into the welded frame *A* of heavy structural beams and plates. One end of the shaft was anchored by means of a block *B* and a cross beam *C;* at the other end a load beam *D* was bolted to the flywheel flange. Dead weights could be hung on this beam. Various points on the crankshafts were marked by light punch-marks 180 deg. apart at the root of the fillets of the various arms or spacers, about 0.05 to 0.06 in. away from the adjoining cheeks. In these punch-marks were clamped the points of carriers for the mirrors *E* and *F*. Designation letters, as shown in Fig. 1, were marked on the crankcase adjacent to the points indicated.

The beam was loaded in such a way that the torque on the shaft was increased or decreased by increments of 4000 lb-in. The torques were in this way first raised to 16,000 lb-in., or to 24,000 lb-in., plus the torque of the load beam itself, and then reduced to zero again. The deflection of the mirrors was determined by the scale *G* and the telescope *H* (Fig. 2), the angular deflection in radians being the scale deviation, as read, divided by twice the distance from the mirror to the scale. The readings for each part of the shafts were repeated by two observers and all the readings averaged for torque increments of 4000 lb-in. In addition to readings for single parts of the shafts, readings were taken also for the deflection of the shafts as a whole and for certain subdivisions of them. All these averaged data are recorded in Table 1, the tabulated figures being 1000 times the actual deflections in radians.

Examination of Table 1 indicates that the measurements involve noticeable errors, as might be expected. Parts that should be exactly alike on all shafts show angular deflections which in some cases differ from one another by 10 per cent and even

TABLE 1—DEFLECTION OF CRANKSHAFTS[14]

Part of Shaft	Designation	Number of Shaft 1	2	3	4
Bearing	A-B	0.341	0.342	0.339	0.306
Short Arm	B-C	0.263	0.262	0.257	0.252
Crankpin	C-D	0.195	0.181	0.191	0.169
Long Arm	D-E	0.211	0.372	0.433	0.495
Crankpin	E-F	0.215	0.211	0.215	0.223
Short Arm	F-G	0.204	0.249	0.258	0.241
Bearing	G-H	0.215	0.194	0.221	0.221
Short Arm	H-J	0.221	0.252	0.255	0.256
Crankpin	J-K	0.163	0.162	0.172	
Spacer	K-L	0.143	0.170	0.138	0.460
Crankpin	L-M	0.167	0.162	0.155	
Short Arm	M-N	0.213	0.232	0.242	0.218
Bearing	N-P	0.185	0.187	0.191	0.201
Short Arm	P-R	0.193	0.219	0.215	0.215
Crankpin	R-S	0.174	0.195	0.193	0.202
Long Arm	S-T	0.189	0.261	0.300	0.339
Summation	*A-T*	*3.292*	*3.651*	*3.775*	*3.798*
Measured	A-T	3.312	3.760	3.728	3.835
Summation	*A-G*	*1.429*			
Measured	A-G	1.421			
Summation	*A-H*		*1.811*		
Measured	A-H		1.902		
Summation	*B-G*		*1.275*	*1.354*	*1.380*
Measured	B-G		1.311	1.345	1.401
Summation	*H-T*	*1.648*			
Measured	H-T	1.685			
Summation	*P-T*		*0.675*	*0.708*	*0.756*
Measured	P-T		0.727	0.742	0.798

[14] The figures given are the deflections multiplied by 1000, in radians, for 4000 lb-in. torque. The lines printed in roman are for deflections measured directly; those in italics are values obtained by a summation of the individual deflections.

[12] See *Maschinenbau*, Dec. 17, 1925, p. 1223.

[13] See *Zeitschrift des Vereines Deutscher Ingenieure*, May 2, 1925, p. 601.

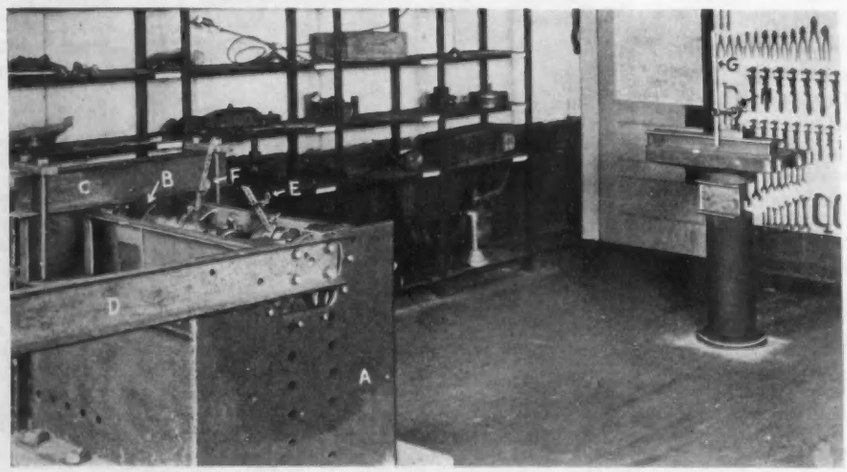


FIG. 2—SET-UP FOR MEASURING CRANKSHAFT DEFLECTIONS

The Inverted Crankcase Is Mounted in a Welded Support *A*. The Crankshaft Is Held Against Turning by Block *B* and Beam *C*. A Weight Is Applied at the End of Arm *D* and the Deflection Is Measured Through Mirrors *E* and *F* by Viewing Scale *G* through Telescope *H*

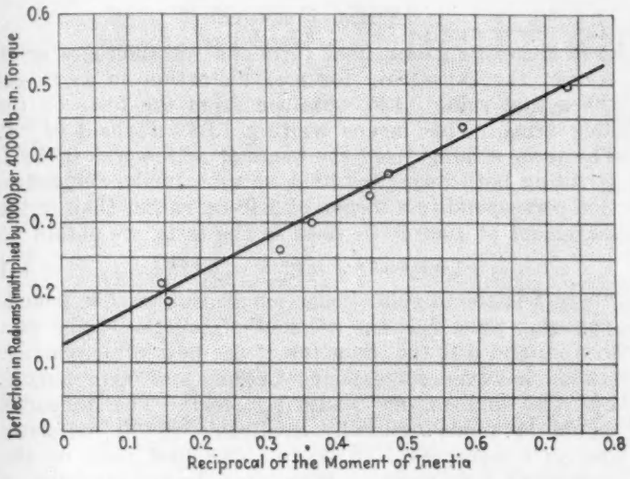


FIG. 3—DEFLECTION OF LONG ARMS OF CRANKSHAFT

more. This may be due partly to inaccuracies in reading on the scale the rather small deviations, or to some distortions in the bearings or the anchorage. There are also, however, possibilities of slight differences in material or in the way the fibers have aligned themselves in drop forging, or perhaps in the way the oil passages are drilled through certain journals and short arms. Nonetheless it is possible to draw some conclusions of considerable practical importance from such an examination.

Thus the differences do not appear very great between (*a*) the angular deflections of the whole shafts or considerable portions of them, as measured directly, and (*b*) the sums of the deflections of the parts making up these portions. They are practically nothing in some cases. In the extreme case, part P-T of shaft No. 2, it amounts to 7.7 per cent. On the average, the actual deflection of a certain portion of the shaft may be taken as 3 or 4 per cent greater than the sum of the deflections of its component parts. Theoretically, there should be such an excess. It is due to the fact that the total angular deflection is made up not only of the angular deflections of the component parts, but also of the bending of the crankpins, the transverse distortion of the arms, and other elements. A very good drawing showing this effect is given by Glenn D. Angle[15]. Evidently the effect can be neglected for the purpose of practical computations, since it is entirely within the magnitude of the errors involved.

DEVELOPMENT OF FORMULAS

Now comes the task of interpreting the results obtained and translating them into formulas suitable for practical use. The formulas for the distortion of journals and crankpins are well known. The problem is merely to evolve practically convenient formulas for the crank-arms. In so doing, the simplest assumption is that the angular deflection of the arms is due simply to bending.

The formula for the angular deflection in radians of a cantilever beam clamped at one end and loaded by a force P at the other end is

$$\text{Angular deflection} = PL^2/2EI \qquad (1)$$

where L is the length of the beam, I the moment of inertia of its cross-section, and E the modulus of elasticity of the material. The question is: Can a crank-arm be regarded as a beam clamped at one end and acted on by a concentrated force at the other? In our case all deflections are referred to a torque increment of 4000 lb-in. The length of all the long arms is the same also; namely, twice the crank radius (2.5 in.) multiplied by the cosine of 30 deg. This is 4.33 in. Also, the modulus of elasticity is a constant. Hence, the angular deflection should vary inversely as the moment of inertia. In Fig. 3 the angular deflection has been plotted against the reciprocal of the moment of inertia, and it will be seen that the points can be represented very fairly by a straight line; in fact, the accuracy is surprisingly good. However, the line does not go through the origin. It is represented by the equation

$$1000\,f = 0.125 + 0.51\,I \qquad (2)$$

where f is the deflection in radians per 4000 lb-in. of torque, and I is the moment of inertia of the arm section. Hence, the angular deflection is not due simply to a bending action with one end of the arm regarded as clamped.

A further investigation of the nature of the term 0.125 is necessary. Before we proceed to this investigation we may, however, examine how closely the last term agrees with our simple formula (1). Taking the bending force as 4000/2.5, or 1600 lb.; the length as 4.33 in.; and the modulus of elasticity as 30,000,000, which may be a trifle high, we find

$$\frac{PL^2}{2E} = \frac{1600 \times 4.33^2}{2 \times 30{,}000{,}000} = \frac{0.50}{1000}$$

or almost exactly equal to the constant 0.51 in formula (2), divided by 1000, as it should be.

It should be observed that the force P does not act at right angles to the chord of the long arm, but at an angle of 30 deg. with the normal, and it should therefore be multiplied by the cosine of 30 deg. if the arm were straight. However, the arms of the crankshafts

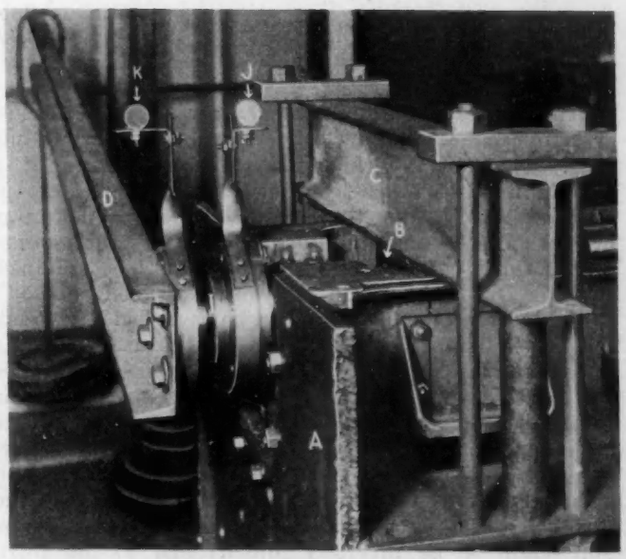


FIG. 4—SET-UP FOR MEASURING ROOT DEFLECTION OF CRANK ARMS

With the Crankshaft Mounted as in Fig. 2, Weight Arm *D* Is Bolted to Test Member *I*. The Deflections Are Read in Mirrors *J* and *K* as Shown in Fig. 2

[15] See Engine Dynamics and Crankshaft Design, p. 131, Airplane Encyclopedia Co., Detroit.

used were bent so as to end almost radially, and under such circumstances it evidently is advisable to introduce the full value of the tangential force.

Root Deflection of Arms

It was thought that the constant term 0.125, in formula (2), must be due to a distortion at the root of the arms, since the adjoining crankpins were the same in all cases. To establish a curve relation between the distortion and some dimension of the pins it was, however, necessary to obtain a series of roots with varying diameters. Such a series was obtained by bolting to the flywheel flange of the shafts an intermediate piece, *I*, as shown in Fig. 4. This piece contained a throat with fillets very nearly equal to those of the pins at the crank cheeks. The two fillets of the throat corresponded in amount of distortion to the fillets at each end of the crank-arm, both being comprised within the punch-marks to which the mirror carriers were attached. The diameter of each of the pins and journals of the shafts was 2⅜ in. The throat was turned down successively from this diameter to 2, 1¾, and 1½ in. A series of deflection measurements was obtained by means of the mirrors *J* and *K*, mounted as shown in Fig. 4. These deflections, plotted against the reciprocal of the third power of the throat diameter, gave the straight-line relation shown in Fig. 5. The lowest point corresponds to the diameter 2⅜ in. which was the diameter of the crankpins and main bearings of the crankshafts used. It will be seen that it is quite close to the value 0.125, obtained for the constant term in formula (2), for the angular deflection of the crank-arms, although the line drawn will give a somewhat lower value than this. The equation for the line is

$$1000\,f = 1.44/d^3 \qquad (3)$$

where f is the deflection and d is the throat diameter.

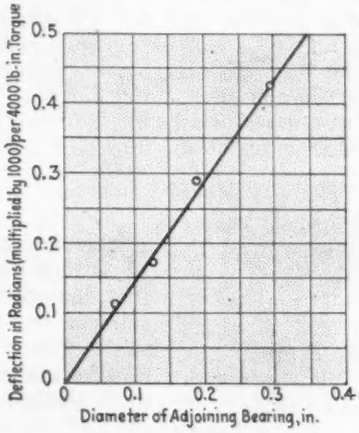


Fig. 5—Root Deflection in Crankarms

If the root distortion of the arms were simple torsion it ought to be inversely proportional to the polar moment of inertia, which is proportional to d^4. But, a plot against d^4 gave at least one point considerably out of line and, in addition, seemed to leave a deflection even when d became infinite. However, the occurrence of the third power of the diameter can be explained. Already Dr. Seelmann in his work previously quoted[13], suggested that the crankpin can be regarded as extending some distance into the arm, as the arm certainly is not infinitely stiff at the bearing. The question is how far to assume that it extends. It seems that simple similarity demands an assumption proportional to the pin diameter. Angular distortion of a cylinder is, however, proportional directly to the distorted length and inversely to the fourth power of the diameter. If the length is put proportional to the diameter, the distortion ought to be inversely proportional to the third power of the diameter.

Final Formulas

In developing our final formulas we shall prefer to correct the expression for root distortion so as to get the actual value 0.125, obtained from the tests on the long arms. This means writing $1.68/d^3$ for $1.44/d^3$. The term arising from the bending action was $0.51/I$. Dividing both terms by 4000, so as to make the deflection correspond to a torque of 1 lb-in. rather than to the increment of 4000 lb-in. used in the tests, we obtain

$$1{,}000{,}000\,f = 0.42/d^3 + 0.128\,I \qquad (4)$$

where f is the angular deflection in radians per pound-inch of torque, I is the moment of inertia of the arm section, and d is the diameter of the adjoining bearing.

This however corresponds to only one arm length, 4.33 in., and to one material, steel. The formulas should be made generally applicable to all materials and all dimensions. To do this, the first term on the right-hand side must be multiplied by the modulus of elasticity of steel in shear, say 12,000,000, and divided by the modulus G of the actual material used. It then becomes $5{,}000{,}000/d^3G$. To generalize the second term we write formula (1) in the form

$$f = \text{Torque} \times L^2/2rEI$$

where r is the crank radius. Evidently, for generalization, the second term in formula (4) must be multiplied by the radius of the actual crankshaft used (2.5 in.), the modulus of elasticity of steel (30,000,000), and L^2. It must be divided by the square of the length of the crank-arms used (4.33^2), r and E. It then becomes $510{,}000\,L^2/rEI$. Leaving out superfluous multiples of 10 on both sides, we obtain as our final formula

$$f = \text{Torque}\,(5/d^3G + 0.51\,L^2/rEI) \qquad (5)$$

This applies more particularly to arms ending radially. For a long arm that is not bent, but forms an angle α with the crank radius at its ends, it is possible that the equation should be made to read

$$f = \text{Torque}\,(5/d^3G + 0.51\,L^2\cos\alpha/rEI) \qquad (6)$$

For this assumption we have, however, no experimental verification.

Formula (5) can be verified by the deflection of the short arms, of which no less than 20 were tested on the four shafts under test. Their length is 2.5 in., and the moment of inertia of their cross-section can be taken as 1.55, although it varies considerably because the arms were not finished. We find for the angular deflection for a torque of 4000 lb-in.,

$$f = 4000\,(5/2.375^3 \times 12{,}000{,}000 + 0.51 \times 2.5^2/2.5 \times 30{,}000{,}000 \times 1.55) = 2.34/1000$$

The deflection for the 20 arms as determined experimentally averages 2.36 / 1000. This, then, is a surprisingly good check, considering particularly that the arms are so short that the adjoining journals almost overlap.

A New Electrical Engine-Indicator

By E. J. MARTIN[1] AND D. F. CARIS[2]

SEMI-ANNUAL MEETING PAPER — *Illustrated with* PHOTOGRAPHS, DRAWINGS AND CHARTS

AFTER enumerating the fundamental qualities that make an engine indicator successful, the authors classify existing indicators and discuss a few of the more successful ones.

Then is introduced the new electrical indicator, which makes its record from variation between the resistances of two carbon-piles which form the branches of a Wheatstone bridge.

The pressure element is a thin diaphragm flush with the inner walls of the combustion-chamber. This is connected by an invar rod to a cantilever spring, the displacement of which reduces the resistance in one carbon-pile and increases the resistance in the other.

The diagram is recorded by either an ordinary oscillograph or a portable cathode-ray oscillograph. Diagrams taken with this indicator are presented to illustrate its performance under varied conditions. A natural frequency of more than 3000 cycles per second makes possible the faithful recording of phenomena having frequencies as high as 800 cycles per second.

MEASURING the pressure in the cylinder of an engine by the use of an instrument began with the early attempts to improve the steam engine about 1800, when the Watt indicator was introduced. This was a simple mechanical device that could be calibrated and with which valuable information was obtained. As the engine was developed, the rôle of the indicator became more exacting, with the result that many improvements and new instruments were devised. During those years the problem was relatively simple, because the speeds were low and the engine usually was large enough to afford a solid base upon which to mount the indicator and its parts.

With the advent of the internal-combustion engine, the indicator problem became much more difficult. Compared with the steam engine, the speeds were high and the vibration was much more intense; the small combustion-chamber and the general design made it more difficult to attach the indicator; and the very rapid pressure-changes during the cycle, as well as the high temperatures, further increased the difficulties.

As the internal-combustion engine has become of such economic importance that every effort is being made to improve its performance, a satisfactory indicator should be of considerable assistance to the research engineer in his investigations of valve-timing, cam profile, spark-plug position, combustion-chamber design, fuel characteristics, and compression ratios. Used in bombs or engine combustion-chambers, it should aid the study of detonation and the action of knock inducers and suppressors.

PROPERTIES OF A GOOD INDICATOR

To render the most assistance in the investigations mentioned, an indicator should have the following characteristics:

(1) *Flush Mounting.*—That part of the indicator to which the pressure is applied should be flush with the inner wall of the combustion-chamber. Connecting tubes and passages and changes of chamber volume should be avoided because they detract from the certainty of the results, especially if the results are unusual or unexpected, as they may be in fundamental research. For purposes of comparison, however, where the type of combustion is more or less normal, flush mounting may not be so important. The importance of flush mounting for fundamental investigations is emphasized by results obtained with the indicator that is introduced in this paper

(2) *High Natural Frequency.*—To give a faithful record, a recording instrument must have a natural frequency at least four times that of the phenomenon to be recorded; therefore, in studying the nature of detonation, a phenomenon in which high-velocity reactions have long been suspected, an indicator having a very high natural frequency is necessary. Such an instrument is less susceptible to engine vibration and introduces less lag into the record than a more sluggish indicator does. Unless a very light pressure-element is used, it is difficult to obtain a high natural frequency together with sufficient sensitivity to produce records of useful size

(3) *Low Inertia.*—Unless the pressure element and the attached members are of small mass, engine vibration causes disturbances which make the card difficult to interpret. The inertia forces upon the pressure element should be negligible compared with those resulting from engine pressure

(4) *Proper Damping.*—So that it will not superpose its own natural oscillations upon the record, the indicator should be properly damped. This is usually best accomplished by means of some type of fluid friction. Mechanical or rubbing friction usually introduces hysteresis

(5) *Minimum Friction.*—Besides introducing hysteresis, friction interferes with proper calibration and makes uncertain the line representing atmospheric pressure. Indicators depending upon the action of a small piston usually give trouble from friction because of the tight fit necessary to prevent leakage

(6) *Accuracy.*—The instrument should give quantitative results and be easily calibrated. A linear relation between pressure and deflection is desirable. Calibrations before and after a test

[1] Physicist, General Motors Corporation Research Laboratories, Detroit.

[2] General Motors Corporation Research Laboratories, Detroit.

should be identical or should not differ more than is consistent with the accuracy of other measurements made in the test. If temperature influences the sensitivity, some means of cooling should be provided and the calibration should be made at the temperature of operation. So far as possible, all springs and diaphragms should be located where temperature variations are small

(7) *Ease of Attachment to Any Engine.*—It should not be necessary to design and construct elaborate supports and driving members to operate the indicator. On the contrary, it is desirable to be able to take indicator cards with the engine propelling a car under normal operating-conditions

(8) *Adaptability.*—By means of minor adjustments or changes an indicator should enable the investigator to observe and record either single or composite diagrams on either pressure-volume or pressure-time scales. A means for obtaining both "offset" and "weak-spring" diagrams should be provided.

Many indicators are of such a nature that the pressure in the combustion-chamber must be communicated to them through a body of gas in a tube or other channel. Since the confined gas must faithfully transmit the combustion-chamber pressure to the indicator, the transmission means should possess the qualities outlined in paragraphs 2 to 5 to the same degree as the indicator itself. This is not taking into consideration what might happen if the combustion in the chamber should spread into the tube. If the indicator requires an electrical instrument as a recording means, that also should possess the same qualities.

We should fully appreciate the problems involved, as well as the ingenuity that has been used, in attempts to develop satisfactory indicators. To help in this it seems advisable to classify indicators and discuss a few that have been developed.

Mechanical Indicators

All indicators in which the connecting linkage between the pressure element and the recording stylus or pencil is purely mechanical fall in the class of mechanical indicators. Most of them are handicapped by friction, lost motion, low natural period, and inertia. The first indicator by James Watt, in 1800, was followed by others such as the Richards, Crosby and Dobbie-McInnes, some of which have been used with considerable success on internal-combustion engines.

The micro-indicator[3], designed by W. G. Collins, of the Cambridge & Paul Instrument Co., is of considerable interest. Fig. 1 shows two views of this instrument. The engine pressure displaces a piston, having a head area of ¼ sq. in., against the elastic restoring force of a cantilever spring. The free end of the spring projects some distance beyond the point at which the piston is connected and acts as a multiplying lever, carrying a recording stylus which scratches the card on a reciprocating sheet of celluloid. As the displacement of the stylus is several times the piston displacement, none of the usual multiplying levers are used and lost motion is thereby avoided. The natural frequency is about 1100 cycles per second. The diagrams are less than ⅛ in. square and must be studied through a low-power microscope. Its relatively high natural frequency enables this indicator to show the disturbing effect of the air passage leading from the combustion-chamber to the pressure element.

Optical Indicators

As a class, optical indicators are characterized by the use of a beam of light as the means of amplifying the motion of the pressure element, which may be either a small tight-fitting piston or a diaphragm. The beam of light, reflected from a small mirror, is given two motions, one from the instrument piston or diaphragm and the other a uniform rotation or reciprocation in phase with the engine piston. The beam impinges upon a stationary photographic plate or sensitized paper. By the use of small mirrors and a stationary photographic plate, the optical indicator is suitable for relatively high-speed work. The large amplification obtained with a beam of light acting as a lever reduces the necessary displacement of the piston or diaphragm, thereby reducing the wear and fatigue and at the same time making it possible to design instruments with relatively high natural frequencies. The mirrors must be very carefully mounted to avoid lost motion. All indicators employing a piston give trouble because of friction, leakage and vibration.

An optical indicator having a piston as its pressure element is the well-known Hopkinson instrument shown in Fig. 2. The Burstall indicator[4] is similar in design to the micro-indicator already mentioned, except that the motion of the cantilever spring is magnified by means of a mirror and beam of light before being recorded. The natural frequency is from 1200 to 1700 per sec., which is sufficiently high to enable the indicator to record the disturbing effects of the short connecting tube. In the Midgley indicator[5] the usual piston is mounted flush with the wall of the combustion-chamber, eliminating uncertainty from connecting tubes. In the Thring high-pressure indicator[6], designed for use with rifles, the pressure on a small piston changes the lengths of two co-axially connected steel tubes so that one is shortened and the other lengthened. For a pressure of 50,000 lb. per sq. in. the piston displacement is 0.02 in. The frequency is about 15,000 cycles per sec., and the diagrams obtained on a photographic plate are relatively free from vibration.

Of the optical indicators employing a diaphragm, the Dalby-Watson[7] is perhaps best known. The corrugated diaphragm is partially cooled by a water-jacket just below it to eliminate, so far as possible, warping and changes of elastic properties produced by heating. Although the amplification obtained with the optical system is comparatively great, the displacement of the diaphragm is sufficient to cause trouble from fatigue.

Sampling-Valve Indicators

The sampling-valve indicator is an ordinary mechanical indicator connected to the engine by a tube containing a valve operated by the engine through gears. The valve is open during only a small part of each cycle, and the pressure in the expansion chamber of the indicator builds up until it equals the average pressure in the engine during the time the valve is open. By selecting gears having the proper ratio, the timing of the valve is changed progressively so that, in the course of a 1000 or more cycles, the mechanical indicator used as

[3] See *Engineering*, June 9, 1922, p. 716.
[4] See *Engineering*, Jan. 26, 1923, p. 121.
[5] See THE JOURNAL, April, 1920, p. 254.
[6] See *The Engineer*, March 16, 1928.
[7] See *Proceedings of the Institution of Automobile Engineers*, vol. 3, p. 387; and *Engineering*, Feb. 27, 1925, p. 257.

a recorder measures all the pressures in one cycle. The drum of the mechanical indicator is driven from the same gears that operate the valve and may have either a slow uniform motion or a reciprocating motion following the valve as it progresses through one cycle of the engine.

This method of obtaining diagrams was originated by K. J. De Juhasz[8] in 1919 and has been considerably improved since. The diagrams are often characterized by irregular "spiked" outlines. The irregularities probably are caused at low speeds by insufficient inertia in the recording mechanism, by leakage, and perhaps by engine vibration; and at high speeds by the irregularities of combustion combined with too light a recording mechanism, by the disturbing effects of the connecting tube, and by engine vibration. Increasing the weight of the recording piston, reducing leakage, and designing a very good rotating valve enabled Gale[9] to use this method in obtaining composite cards that were relatively free from irregularities. In his latest paper M. De Juhasz[10] also shows high-speed diagrams that are virtually free from them.

Professor Jacklin[11] connects an indicator of this type to all the cylinders of an engine through a selector valve which enables him to obtain a complete set of cards in a short time. The composite diagram obtained with such an indicator should yield useful information if properly interpreted. When adapted to record simultaneously the composite diagrams from the several cylinders of a multi-cylinder engine, such an instrument should afford a ready and fair means of comparing pressures.

Electrical Indicators

In some instruments an electrical current is employed as a means of producing the record. Indicators in this class have the advantage that it usually is unnecessary to mount the recording apparatus on the engine or even very near it. To produce single diagrams electrically, some form of electrical recording instrument is necessary, and this must be damped properly and have a sufficiently high sensitivity and natural frequency to produce a faithful record.

The electrical indicator of Prof. Augustus Trowbridge[12] is of interest because it measures the rate of pressure rise instead of the pressure itself. Pressure against a diaphragm carrying a small coil of wire in a strong magnetic field generates a current which is recorded by means of a string oscillograph. The resulting record must be converted into a pressure-volume or pressure-time diagram. This indicator has not been used extensively.

An indicator employing a balanced diaphragm was used by Prof. Bertram Hopkinson[13] before 1913 and has

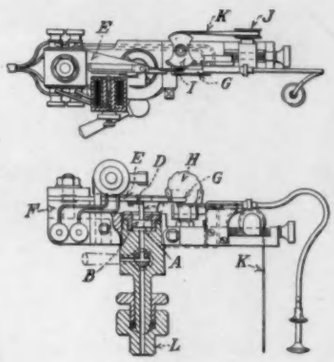


Fig. 1—Two Views of the Micro-Indicator

The Free End of the Cantilever Spring Carries a Stylus Which Can Make Several Minute Diagrams on the Same Notched Disc of Celluloid. The Parts Are: *A*, Cylinder-Liner; *B*, Piston; *C*, Piston-Rod; *D*, Subsidiary Spring; *E*, Cantilever Pressure-Spring; *F*, Frame; *G*, Stylus; *H*, Celluloid Disc; *I*, Cylinder for Holding Celluloid; *J*, Adjustable Guide-Pulley; *K*, Steel Tape; *L*, Adapter

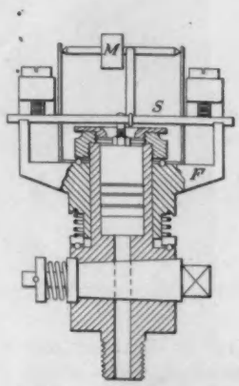


Fig. 2—Hopkinson Optical Indicator

The Frame *F* Is Mounted on Ball-Bearings and Is Given an Oscillating Motion Corresponding to the Movement of the Piston. The Movement of the Double-Cantilever Springs *S* Causes the Mirror *M* To Tilt. A Beam of Light Reflected from the Mirror Traces the Diagram on a Photographic Film

since been considerably improved by the Bureau of Standards[14]. By means of a tank containing compressed air, a series of pressures of sufficient range to include all pressures developed in the engine is applied to one side of a diaphragm, the opposite side of which is subjected to engine pressure. The diaphragm is connected in series with a battery and telephone receiver and a commutator driven by the engine. The commutator brush can be rotated so as to complete the electrical circuit through the telephone at any point in the cycle. While the disc is making contact, a click is heard in the receiver for each revolution of the commutator. When the engine pressure is just greater than the external pressure applied to the diaphragm, the latter is displaced and breaks the circuit. If the commutator brush is rotated to a position where it completes the circuit at the time the diaphragm has the circuit broken, no click is heard. For each external pressure applied to the diaphragm the brush is rotated until no clicks are heard in the receiver, the positions of the brush being read on a protractor. The external pressures are plotted against protractor readings. The resulting diagram may be converted into pressure-volume or pressure-time diagrams, provided the engine speed is known and does not change while taking the readings.

An ingenious method of obtaining indicator cards has been developed by J. Obata and Y. Yosida[15]. One plate of a small condenser is a diaphragm which is displaced by the pressure from the engine. The resulting change in capacity produces a very small electric current which is amplified by a vacuum-tube amplifier and recorded by an oscillograph. This indicator has a natural frequency as high as 12,000 cycles per sec. The long connecting tube and the amplifier are undesirable features.

The Farnborough, or Royal Aircraft Establishment, indicator[16] is similar to the balanced-diaphragm type. A small disc-valve serves as the balancing member and

[8] See *Automotive Industries*, Feb. 7, 1924, p. 298.

[9] See *The Engineer*, Sept. 24, 1926, p. 332.

[10] See *Instruments*, April, 1928, p. 179.

[11] See The Journal, March, 1928, p. 337, and *Purdue Engineering Review*, January, 1928, p. 7.

[12] See *Power*, May 3, 1921, p. 704.

[13] See *Engineering*, Jan. 24, 1913, p. 109.

[14] See National Advisory Committee for Aeronautics Report 107, p. 635.

[15] See Aeronautical Research Institute, Tokyo Imperial University Report 7 on Electrical Indicators for High-Speed Internal-Combustion Engines.

[16] See *Proceedings of the Institution of Mechanical Engineers*, January, 1923, p. 137.

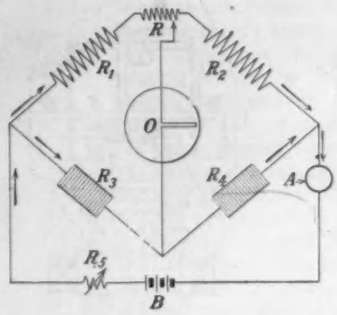


FIG. 3—DIAGRAM OF WHEATSTONE BRIDGE WITH CARBON STACKS

The Units Are: *A*, Ammeter; *B*, Storage Battery; *O*, Oscillograph; *R*, 40-Ohm Copper-Wound Balancing-Rheostat; R_1 and R_2, 40-Ohm Resistance; R_3 and R_4, Carbon Stacks; R_5, 40-Ohm Variable Rheostat

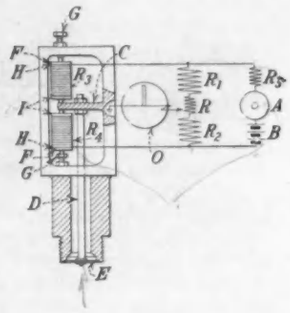


FIG. 4—INDICATOR AND CIRCUIT

C, Tongue Acting as Cantilever Spring; *D*, Invar Push-Rod; *E*, Diaphragm; *F*, End Pressure-Plates; *G*, Adjusting Screws; *H*, Copper Connection-Plates; *I*, Central Pressure-Plates. Other Letters Are the Same as for Corresponding Parts in Fig. 3

breaks the primary circuit of an ignition coil. The spark from the secondary pricks a hole in a sheet of black paper revolving on a drum driven by the engine. The spark point is displaced along the drum parallel to its axis by the external pressure applied to the balancing valve. A card is obtained by applying a sufficiently high external pressure to the balancing valve and allowing it to diminish slowly while the engine is running. Thus a complete pressure-time diagram is obtained in a minute or two, its outline being made visible by removing the black paper and holding it up to the light. Pitting of the balancing valve as a result of its use as an interrupter in the primary circuit causes considerable leakage-trouble unless the valve is frequently removed and ground. In the General Motors Corporation Research Laboratories this pitting is almost completely eliminated by using a power amplifier. Instead of interrupting the primary current of the ignition coil, the balanced valve controls the current in the grid circuit of the amplifier. The spark is produced by a coil in the plate circuit. With this arrangement the current interrupted by the valve is reduced from about 3 amp. to less than 0.1 amp.

PRINCIPLES OF THE NEW INDICATOR

The new electrical indicator which will now be described was developed by taking advantage of work done at the Bureau of Standards by Burton McCollum and O. S. Peters, who developed an instrument for recording electrically the strains in the members of bridges, buildings, ships, and other structures. In their instrument[17], described in 1923, the strain to be measured causes a variation in the longitudinal pressure upon two carbon-pile rheostats, thereby changing the electrical resistance. The strain is communicated to the rheostats in such a way that the resistance of the first is increased while that of the second is decreased. These rheostats, together with two coiled-wire rheostats, form a Wheatstone bridge. Variation of the resistance in the carbon-pile rheostats, caused by the strain, thus produces a deflection of the usual bridge-galvanometer which is proportional to the strain. To record this strain over a period of time, the galvanometer is replaced by an oscillograph.

Fig. 3 is a diagram showing a Wheatstone bridge with the carbon piles represented at R_3 and R_4. The two coiled-wire rheostats, shown at R_1 and R_2, have resistances of about 40 ohms each, which is equal to that of one of the carbon stacks when held in a clamp under sufficient compression to assure stability. The bridge is approximately balanced by adjusting the compression on the stacks by means of set-screws, the final balance being obtained by adjustment of the low-resistance rheostat shown at R. A storage battery supplies the bridge current, which is indicated by the ammeter and controlled by the variable rheostat R_5. Sensitivity of the apparatus depends upon the bridge current; consequently, the ammeter reading must be held constant during a series of tests. Control of the bridge current affords a wide range of sensitivity for various types of test.

Stated briefly, the new indicator is a device in which the engine pressure varies the resistance of two carbon-pile rheostats. This resistance-variation produces in a Wheatstone-bridge circuit an unbalance that is proportional to the pressure and is recorded by an oscillograph.

IMPROVEMENT OF THE CARBON-PILE RHEOSTAT

A carbon-pile rheostat depends for its action upon the contact resistance between the plates that make up the pile. As ordinarily constructed, it is useful only for the rough control of currents in various electrical circuits, because of its erratic behavior, especially when subjected to vibration. In developing their electrical strain-recorder, Messrs. McCollum and Peters found it necessary to improve the carbon-pile rheostat. After considerable research they succeeded in making rheostats that were very uniform in behavior if used under proper conditions. The new piles were made of annular plates having an outside diameter of ½ in., an inside diameter of ⅛ in., and a thickness of 0.015 in. These plates were made of special carbon, and their faces were accurately ground to assure uniform thickness as well as flat surfaces. A pile consisted of from 50 to 75 discs. The resistance of each pile was approximately 1 ohm. When incorporated in a Wheatstone bridge, the low resistance of the piles made it necessary to use rather large bridge-currents, which resulted in considerable heating. Although quite satisfactory for use under many different conditions, the piles were seriously disturbed by vibration.

In 1927, Mr. Peters reported[18] that he had made a great improvement in the electrical strain-recording instrument. Most of the improvement resulted from his development of greatly superior carbon-piles, in which the plates were made of a very hard carbon developed for this purpose by Mr. Peters at the Bureau of Standards. They are of ⅜-in. outside diameter, 3/16-in. inside diameter, and 0.013-in. thickness. Each stack is about ⅝-in. long and has a resistance of approximately 45 ohms when under a compressing force of 20 lb. In the development of various instruments the authors have found the new discs far superior to the

[17] See Bureau of Standards Technologic Papers, vol. 17, p. 737.

[18] See *Proceedings of the American Society for Testing Materials*, vol. 27, part 2.

old ones, and they are very satisfactory as used in the new indicator.

Details of Construction

Fig. 4 is a drawing of the new indicator with a diagram of the necessary electrical circuit. The frame is of oil-hardening tool-steel, machined so that one end is threaded to screw into the combustion-chamber wall. In cutting out the interior of the frame, a tongue *C* is left projecting from one side and extending nearly to the opposite side. The dimensions of the tongue are such that, when loaded with the push-rod *D* and carbon piles R_1 and R_2, its natural period is sufficiently high for the research for which it may be intended. The frequencies of the tongues so far constructed range between 3500 and 500 cycles per sec. The tongue acts as a cantilever spring, the very small deflection of which is a means of measuring the pressure upon the diaphragm *E*. After machining, the frame is heat-treated and then ground to final dimensions. The carbon piles R_1 and R_2 are held between the tongue and the ends of the frame by pressure on the plates *F*, which is controlled by the adjusting screws *G*. The rounded points of the screws fit into recesses in the plates.

At the adjusting-screw ends of the carbon piles are copper plates *H*, to which wires are soldered for electrical connections to the Wheatstone bridge. Between these copper plates and the steel pressure-plates are mica insulating-discs. The ends of the carbon piles nearest the tongue press directly against the steel plates *I*, projections from which fit into recesses on either side of the tongue. With this arrangement, the inner ends of the piles are grounded so that the frame of the instrument can be connected to the third wire, leading to the recording instrument and the Wheatstone bridge.

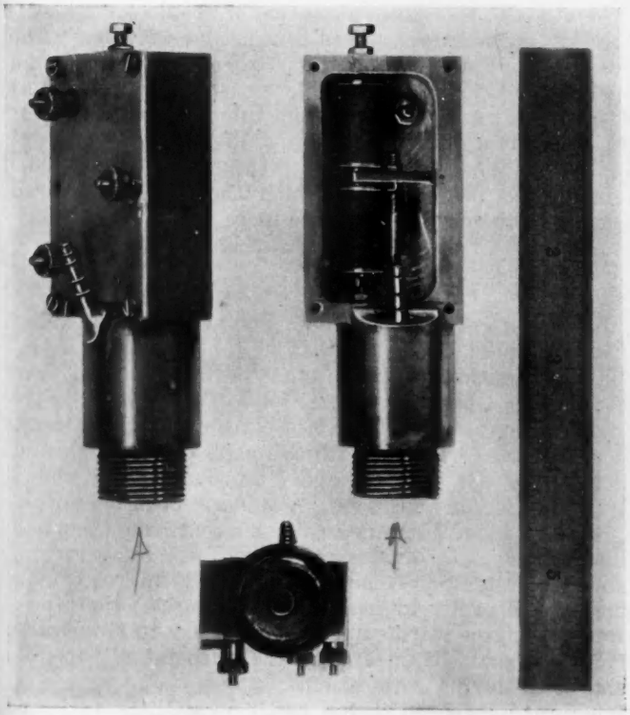


Fig. 5—Photograph Showing Indicator in Three Positions

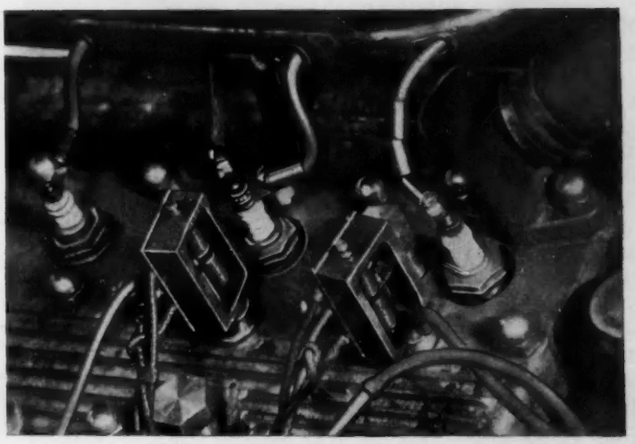


Fig. 6—Two Indicators Ready for Operation

The three wires are the only connections between the recording apparatus and the indicator proper, and they can be incorporated in a three-wire cable 20 to 50 ft. in length. Because of this feature, the recording apparatus need not be subjected to engine vibration.

The connecting link between the diaphragm and the tongue is the hollow rod *D*, made of invar steel to avoid temperature effects. The invar rod expands so slightly that the thin diaphragm is accommodated easily to it without producing an appreciable upward force against the tongue. An invar rod 3 in. long expands only 0.0006 in. for a temperature change of 400 deg. fahr. To produce the same displacement of the diaphragms generally used in indicators of this type, a force of 1.5 lb. would be required. In practice, the rod becomes heated at one end only, being cooled by the stream of air directed against the diaphragm.

Results Independent of Diaphragm Characteristics

The diaphragm *E* is a thin steel disc brazed to the threaded end of the frame and connected at its center to the push-rod. The elastic constants of the diaphragm have no influence upon the records obtained. So great is the sensitivity of the carbon piles, combined with the recording apparatus and the design of the tongue, that so far no work has been done in which the deflection of the diaphragm has equalled 0.0005 in. Operation of this instrument does not depend upon an elastic diaphragm, because the displacements are so small that the restoring forces set up in the diaphragm are negligible compared with those set up in the tongue, which is located where it remains cool. The diaphragm is made of a tough spring-steel sufficiently thick to withstand engine pressures. In designing the instrument to meet special requirements, the dimensions of the tongue and diaphragm are so proportioned that, for a given displacement, the restoring force created by the diaphragm displacement is negligible compared with that of the tongue.

The life of the diaphragm is prolonged by directing a stream of air against it, through the side tube shown in Fig. 5, which shows the indicator from different angles. Without cooling, several diaphragms have lasted through 2 to 4 hr. of continuous operation in engines delivering their maximum power. Use of the air stream is recommended, however, because it will

greatly increase the life of the diaphragm. One diaphragm in the laboratory is in good condition after a total service of more than 24 hr., during which many cards were taken at maximum power, some for very high compression-ratios and others under various detonating conditions. It is probable that the life of the diaphragm could be lengthened considerably by using a better steel. A chromium-vanadium steel that is highly recommended for this type of service will be tried when more of these indicators are constructed. The spring steel being used now gives very good service.

The lightness of the diaphragm prevents the production of any inaccurate results by the shortening of the effective length of the push-rod because of whipping or bowing of the rod that might cause the diaphragm displacement to be increased very slightly. The force necessary to produce such a displacement would be negligible compared with the force acting on it from the engine pressures. If there is any such whipping, it is so small that its effect upon the displacement of the tongue has not been noticeable on the cards.

Oscillograph Used as Recording Apparatus

The recording apparatus may be divided into two parts: the oscillograph and the Wheatstone bridge. The oscillograph may be described as a sensitive recording-ammeter having a moving coil so light that it can follow rapid fluctuations of the current to be recorded. The moving coil carries a tiny mirror which reflects a beam of light upon a photographic film wrapped around a rotating drum. As oscillographs containing from one to twelve recording elements can be purchased, it is possible, by constructing several of the indicators described, to indicate simultaneously the pressures in several cylinders, or to indicate the pressure in one cylinder at several points simultaneously.

It is convenient to have available in the oscillograph one or two extra elements, one of which can be connected to the ignition primary to mark the time of firing, while the second can be connected to a commutating disc mounted on the crankshaft to indicate various points, such as top dead-center. For accurate timing of the card it is convenient to have the commutating disc interrupt a 60-cycle current each time the crank passes top dead-center.

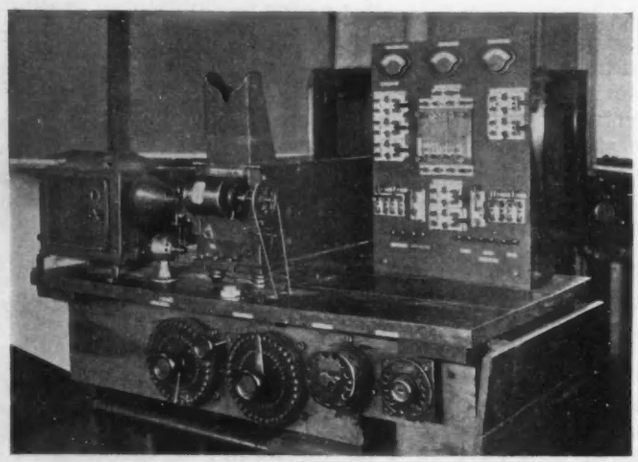


Fig. 7—Oscillograph and Switchboard on Portable Table

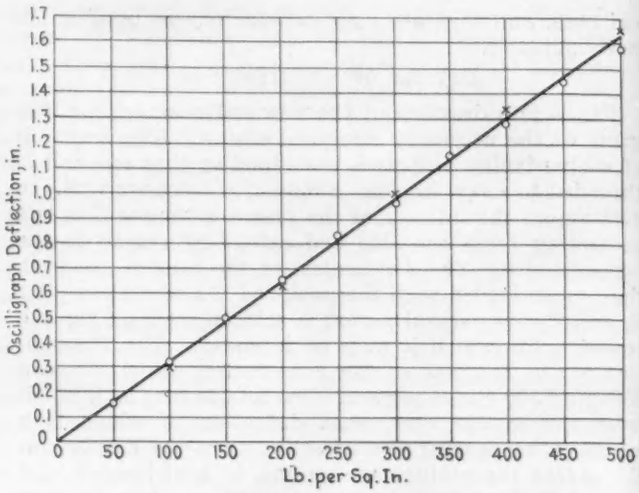


Fig. 8—Calibration Curve for Indicator

The Points Marked *O* Show Tests Before Taking 12 Indicator Cards, and Those Marked *X* Show the Corresponding Tests Made After Each Card

Oscillographs usually are equipped with a rotating mirror that can be shifted into the paths of the beams of light reflected from the elements. This mirror reflects the beams upon a screen and, by adjusting its speed, the diagram can be made to appear stationary for visual study. Shifting the mirror out of the way with one hand by means of a lever and tripping the shutter mechanism with the other hand, a card can be recorded almost while it is being viewed on the screen. As many cards as desired can be recorded on one film simply by holding the shutter switch closed for a sufficient time.

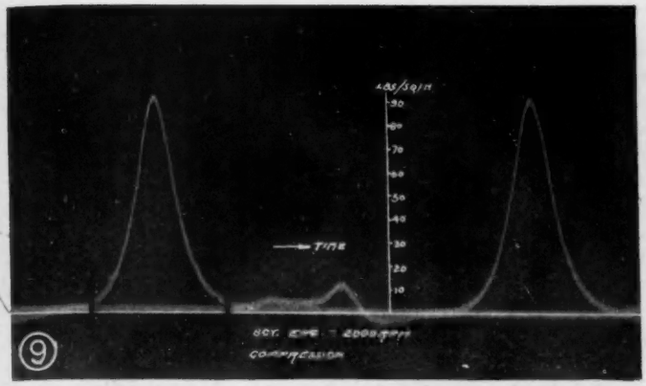
In selecting an oscillograph for use with this indicator, it is to be remembered that it should have a sufficiently high natural period to reproduce faithfully the pressure waves in the engine. The sensitivity should be sufficient to make possible satisfactory deflections with the current output from this instrument. For those constructed so far the maximum current-output has been approximately 25 milliamperes. It should be remembered also that the smaller the current required to operate the oscillograph, the more nearly under ideal conditions will the Wheatstone bridge be operated.

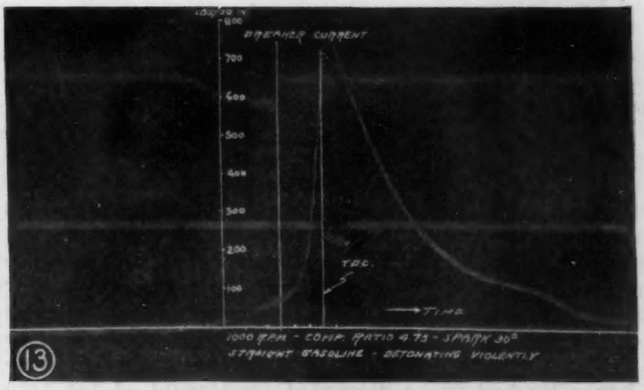
Electrical Circuit and Calibration

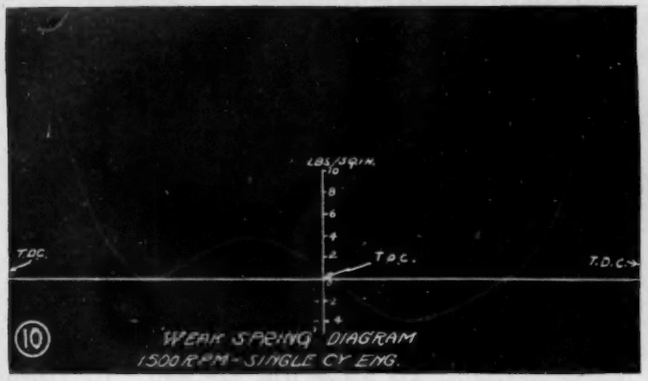
As shown in Fig. 4, the Wheatstone bridge includes the resistances R, R_1, R_2, R_3, and R_4. Of these, R, R_3, and R_4, together with R_5, and the ammeter A, are mounted on a panel in a box about 10 in. square. Five binding-posts are provided, two for the storage battery, B, and three for wires leading to the oscillograph and indicator proper. Figs. 6 and 7 are photographs showing the indicator and recording apparatus in operation.

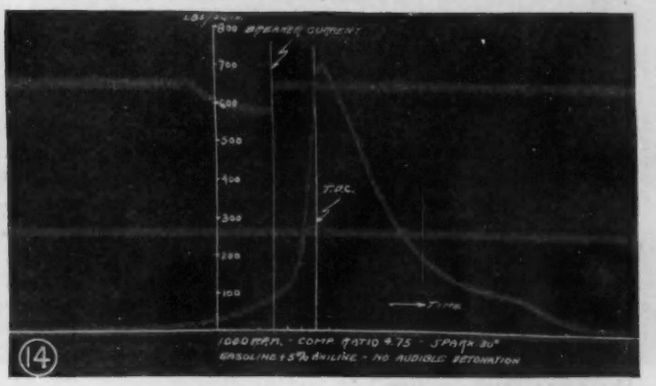
It is important that the bridge current have the same value during a test as during calibration. In operation, the carbon stacks become heated, partly by the bridge current and partly by heat from the engine; therefore, after the engine warms up, it is necessary to reduce the bridge current, by means of the rheostat R_5, to the value used during calibration.

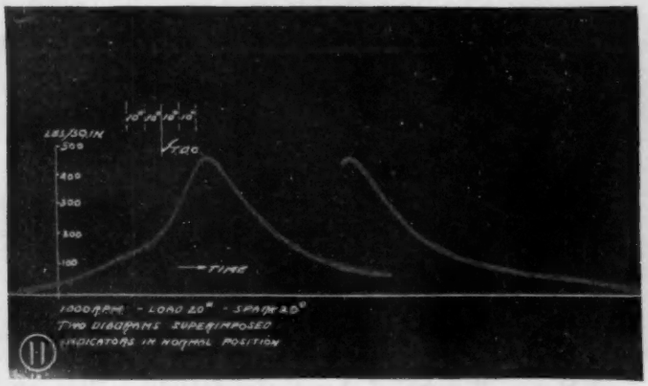
Calibrating the indicator needs very little explanation. Compressed air or nitrogen is valved into a reducing chamber and the pressure is adjusted by means

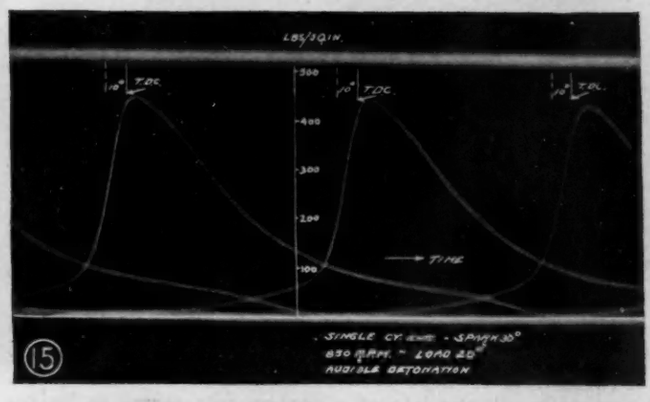


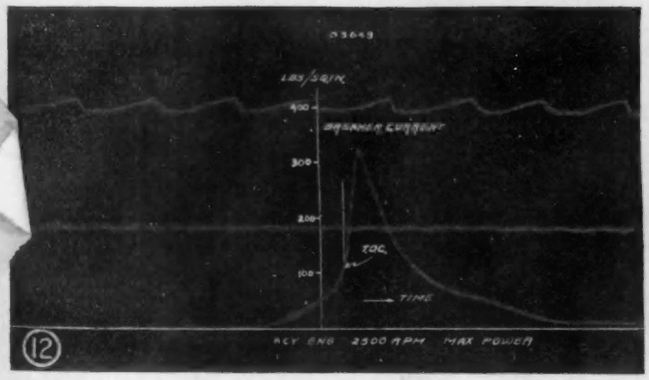


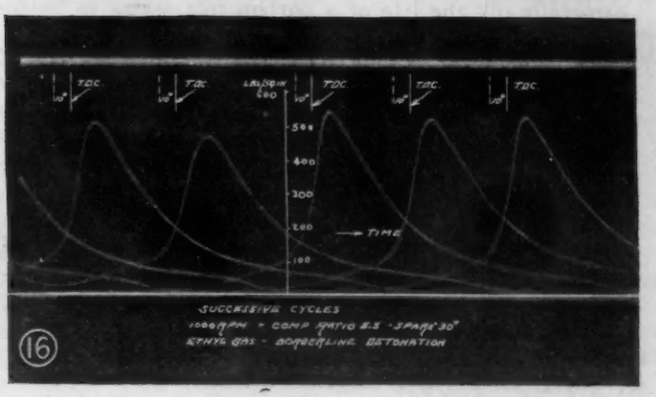












Representative Cards from the New Indicator

Fig. 9—Compression Cards

Fig. 10—Weak-Spring Diagram

Fig. 11—Cards from Two Indicators in the Same Cylinder

Fig. 12—A Diagram Taken at High Speed

Fig. 13—Card from a Detonating Engine

Fig. 14—Card Corresponding to Fig. 13, with Detonation Suppressed

Fig. 15—Successive Cycles from Single-Cylinder Engine with Audible Detonation

Fig. 16—Successive Cycles from High-Compression Engine with Ethyl Gasoline and Borderline Detonation

of a needle-valve and measured with a test gage. The indicator is screwed into the reducing-chamber wall and the usual electrical connections are made. The oscillograph deflection is measured for various pressures throughout the range of pressures occurring in the engine. The resulting deflections, plotted against the corresponding pressures, give a calibration curve such as shown in Fig. 8.

Compressed air or nitrogen is used for applying pressure to the indicator in preference to a weight gage or any other apparatus using oil, because the carbon piles become somewhat erratic in behavior if they are contaminated with oil. This happened once, and the carbon piles had to be discarded on account of the zero shift and temperature effects introduced by the oil.

Temperature Affects the Result Little

If desired, the reducing chamber and indicator may be enclosed in an oven to allow of calibration at the temperature attained by the indicator in actual use. Calibrations have been made at temperatures up to 220 deg. fahr., which is considerably higher than the temperature of the indicator when in operation. Although slight variations were detected, they were small enough to neglect in all ordinary work. In work requiring more than ordinary precision, the operating temperature of the indicator need only be measured roughly and the calibration made in an oven or jacket at about the same temperature.

The effects of temperature are small because the two carbon piles form opposite branches of a Wheatstone bridge. The variation of resistance in one pile, due to temperature change and to change of pressure caused by unequal expansion of carbon and steel, are offset by the same variations in the other pile. If the bridge current is held constant, the sensitivity of the indicator is virtually independent of temperature.

After the carbon piles are assembled and clamped in place, the indicator is "worked in" on an engine for a few hours to allow the piles to become stable. Although very satisfactory for use immediately after such a working-in process, they improve slightly with use. Old indicators have proved the best for very careful work. Provided it is kept free from contaminating liquids, especially oil, the life of a carbon pile seems to be indefinite.

Total errors resulting from the combined effects of zero shift, vibration, and temperature changes usually are less than 3 per cent. None of the indicators of this type used up to the present has shown inaccuracy as great as 5 per cent. Therefore, it seems safe to guarantee the new indicator to be accurate within 5 per cent.

To meet the requirements of ordinary investigations, the necessary equipment may be enumerated as follows:

(1) An oscillograph having a number of elements equal to or greater than the number of simultaneous records desired
(2) A Wheatstone bridge for each indicator-unit
(3) If simultaneous diagrams are desired, a sufficient number of indicators having the same constants should be provided. For weak-spring diagrams, a unit should be provided having greater sensitivity than those intended for regular combustion-work
(4) Apparatus for calibration

Distortion of Photographic Films Is Slight

Occasionally one reads of an engineer advising against the use of film for indicator records because of the uneven expansion and contraction that may occur during the developing and drying processes. Since the new indicator depends upon photographic films for its record, it seems advisable to mention briefly some researches that have been made to ascertain the errors caused by film distortion.

Dr. H. L. Curtis[19] found contractions varying from 0.3 to 1.3 per cent for N. C. film during the drying process. He reported that drying in alcohol made the shrinkage more uniform. Prof. R. W. Cheshire[20] concluded from his work that, if measured when wet, films show an increase in length of about 0.5 per cent. On drying, there is a shrinkage of about 0.2 per cent and eventually a decrease of 1.0 per cent. He also found diurnal variations as great as 0.75 per cent.

That the results obtained by both these investigators are too high is shown by F. E. Ross[21] and others who made similar measurements. Ross found the errors to be very small except near the edge of the film. After extensive and painstaking work he concluded that, if the film was measured immediately after drying, errors due to distortion are below 0.05 per cent. He found seasonal changes of 0.4 per cent, which he attributed to humidity variation.

When one considers the inaccuracies inherent in the indicators developed up to the present, it seems safe to conclude that photographic films are sufficiently free from distortion to be used in such work, for the time being at least.

Performance of the New Indicator

To make clear the performance characteristics of the new indicator, we shall present and discuss briefly some diagrams obtained with it. No attempt at continuity is made, the diagrams being selected from those obtained during several investigations made in the General Motors Research Laboratories recently. They are contact prints from the films made with the General Electric oscillograph.

Fig. 9 shows a compression diagram, the engine being driven by a dynamometer. This card could have been made longer by driving the film drum faster. Fig. 10 is a weak-spring diagram obtained by increasing the sensitivity of the indicator and recording instrument.

The two lines in Fig. 11 show how well the cards agree that are obtained from two indicators very close together in the same cylinder. The bridge currents were set to give the same sensitivity for both indicators, and then their atmospheric lines were made to coincide. This illustrates how consistently pressures in various cylinders or at different points in a given cylinder can be measured. Fig. 12 is a diagram taken at high speed.

The two diagrams in Figs. 13 and 14 illustrate that detonation does not introduce irregularities into the diagram if the indicator is not susceptible to engine vibration and if the pressure element is mounted flush with the combustion-chamber wall. While the card in

[19] See *Journal of the Optical Society of America*, March, 1923, p. 275.

[20] See *Optician and Scientific Instrument Maker*, 1923, p. 288.

[21] See *Astrophysical Journal*, January, 1923, p. 33.

Fig. 13 was being taken, the shock to which the indicator was subjected was dangerous to the engine. These cards also indicate how the second and third elements of the oscillograph are used for recording the time of the spark and the location of top dead-center.

The cards in Figs. 15 and 16 show smooth outlines, although there was considerable detonation when they were taken. In Fig. 16, the pressures are no more irregular when the engine is on the verge of detonation than one would expect them to be under normal operating conditions. These two cards show how a number of diagrams can be taken on the same film without causing confusion. On the usual 12-in. film used with the oscillograph, 25 or more complete diagrams can be recorded, while, with the large film-holder built in our laboratory, 100 or more diagrams can be recorded on one film. This feature affords all the advantages of the ordinary composite diagram, plus a complete record for each diagram on the film.

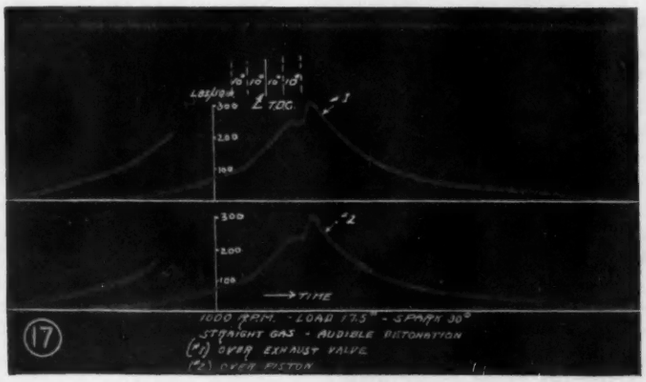
Use of the indicator for studying the effect of detonation on the diagrams taken at different parts of the chamber is illustrated by Figs. 17 and 18. The cards taken over the piston and exhaust valve are nearly identical when there is no detonation, but are somewhat different when there is detonation.

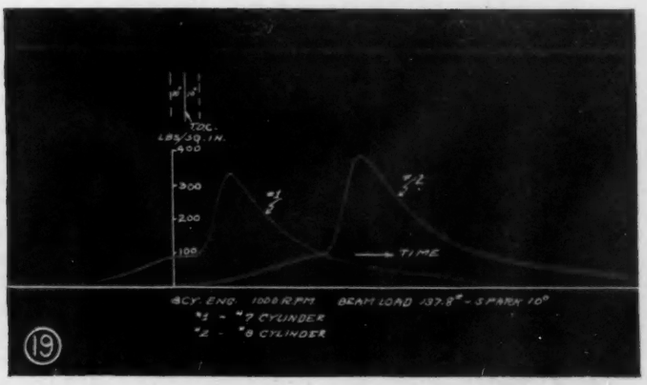
The digarams in Figs. 19 and 20 illustrate how the indicator can be used for studying the variation of distribution with speed.

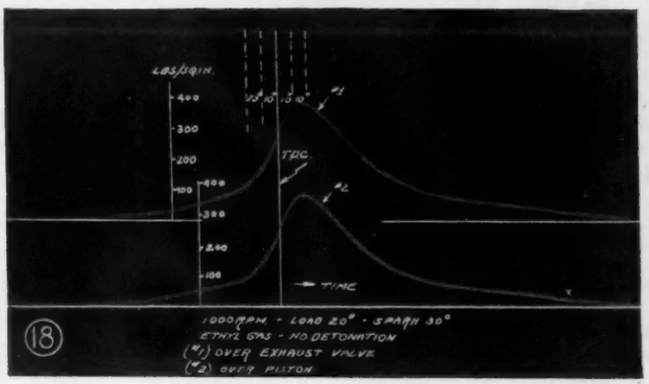
Portable Cathode-Ray Oscillograph

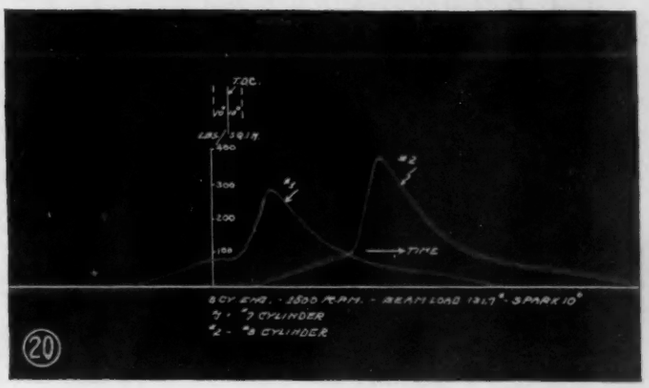
The use of a portable cathode-ray oscillograph in conjunction with the new indicator as a means of studying combustion characteristics is well worth description. It increases the portability and simplicity of the apparatus enough so it can be carried as hand baggage. It also makes possible the study of exceedingly high-frequency combustion-phenomena, because the beam of cathode rays has practically no inertia and can therefore faithfully reproduce upon the screen pressure changes far more rapid than even this indicator can follow. With such a recording device the limiting frequency is that of the indicator, which may be many thousand cycles per second, depending upon its design.

The portable low-voltage cathode-ray oscillograph described by J. B. Johnson[22] in 1922 is as simple to operate as an ordinary radio amplifier-tube. In an ordinary radio-tube the electrons emitted from a hot filament (cathode) strike the plate (anode), where their energy is dissipated in heat. In the cathode-ray oscillograph-tube, electrons from the hot filament pass through a hole in the plate and continue in a straight line until they strike a fluorescent screen attached to the inner wall at the far end of the tube. The impact of the electrons upon the screen produces a small brilliant spot that is easily seen. After passing through the pinhole in the anode, the electron beam passes between two sets of parallel deflecting-plates set at right angles to each other. One set of plates is connected to a circuit controlled by the indicator-bridge current. When the in-









Additional Indicator Cards

Fig. 17—Detonation Measured at Two Points

Fig. 18—Detonation Shown in Fig. 17 Eliminated with Ethyl Gasoline

Fig. 19—Distribution in Eight-Cylinder Engine at 1000 R.P.M.

Fig. 20—Distribution in Eight-Cylinder Engine at 1500 R.P.M.

[22] See *Journal of the Optical Society of America*, September, 1922, p. 701.

dicator is subjected to various pressures, the corresponding current from the bridge displaces the bright spot on the screen by amounts proportional to the pressures. The other pair of deflecting plates is connected to an electric circuit controlled by the engine in such a way that the spot is given a reciprocating motion perpendicular to the displacement caused by the pressure variations. The result is that the diagram is seen outlined upon the screen.

A sketch representing the tube is shown in Fig. 21. The filament is at *C*, while the anode or pinhole tube, which takes the place of the plate in an ordinary radio-tube, is at *A*. The shield *S*, having a hole in its center,

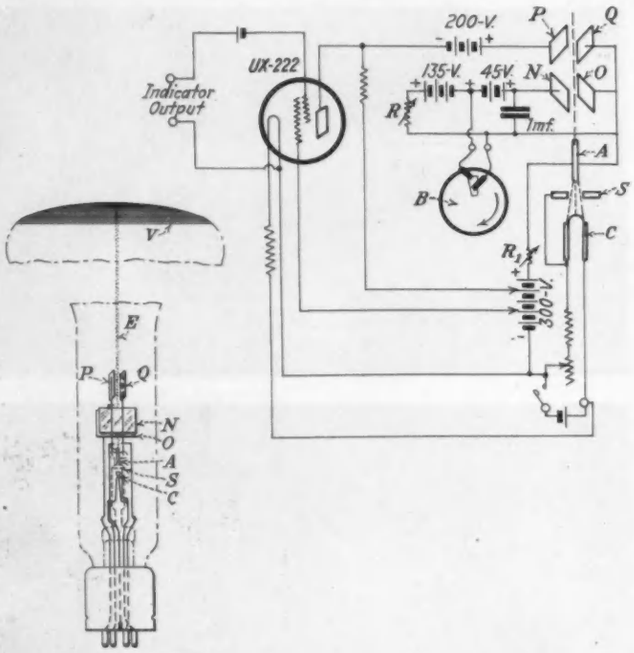


FIG. 21 — SCHEMATIC DIAGRAM OF THE CATHODE-RAY OSCILLOGRAPH

The Elements of this Oscillograph Tube Are: *A*, Anode; *C*, Cathode; *E*, Electrons; *N* and *O*, Lower Deflecting-Plates; *P* and *Q*, Upper Deflecting-Plates; *S*, Shield; *V*, Viewing Screen

FIG. 22—ELECTRIC CIRCUIT FOR CATHODE-RAY OSCILLOGRAPH

Most of the Elements Are Lettered as in Fig. 21. Others Are: *B*, Commutator; *R*, 0.01 to 0.10-Megohm Variable Resistance; R_1, 2000-Ohm Variable Resistance. Various Batteries Are Indicated by Their Voltage Figures

is inserted to protect the hot filament from positive-ion bombardment. The deflecting plates *N*, *O*, *P* and *Q* are shown directly above the pinhole tube through which the electrons are projected toward the viewing screen *V*. The filament is heated by a storage battery, while the battery connected to the pinhole tube *A* is an ordinary 300-volt radio B-battery.

CATHODE-RAY OSCILLOGRAPH HOOK-UP

The life of the cathode-ray oscillograph-tube is determined by that of the filament, which usually is 100 hr. of actual operation. If a switch is so arranged that the filament is heated only while the diagram is being studied, one tube will last through a large number of investigations.

Fig. 22 shows the electrical circuits and tube connec-

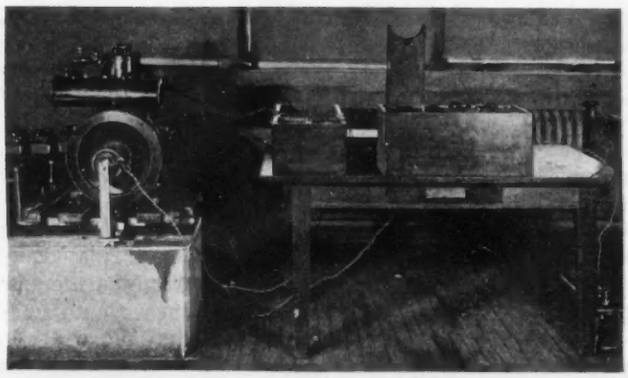


FIG. 23—INDICATOR MOUNTED AND CONNECTED TO CATHODE-RAY OSCILLOGRAPH

tions. The indicator bridge is connected to the grid of an ordinary amplifier-tube of the shielded-grid type. The plate output-circuit of the tube is connected to the upper pair of deflecting plates in the cathode-ray tube. The 200-volt B-battery is used to overbalance the potential drop across the external resistance in the plate circuit of the amplifier tube and to bring the spot near one edge of the fluorescent screen when the indicator is open to atmospheric pressure. This arrangement brings the atmospheric line near one edge of the screen to leave room for large deflections.

The time line is generated by connecting the lower pair of deflecting plates to an electrical circuit, part of which is shorted-out by means of a breaker or commutator disc driven by the engine. The conducting segment of the non-conducting disc subtends about 10 deg. of crankshaft movement. When this segment is under the brushes, the 45-volt battery is connected across the

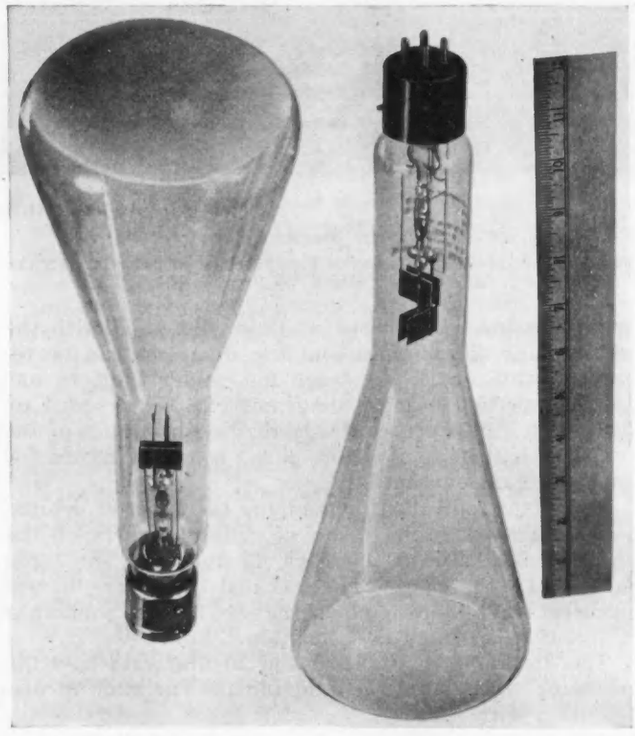


FIG. 24—VIEWS OF TWO CATHODE-RAY TUBES

1-microfarad condenser and the lower deflecting-plates so as to move the spot suddenly over to the left side of the screen. When the segment moves from under the brushes, the 135-volt battery sends a current through the variable resistance *R* and reverses the potential across the condenser and deflecting plates, thereby causing the spot to travel at a uniform rate across the fluorescent screen. As the voltages of the two batteries are such that only the linear part of the charging curve of the condenser is used, the spot moves across the screen at a uniform rate, which can be varied by means of the adjustable resistance *R* to produce long diagrams. In fact, adjusting *R* enables one to spread the diagrams out to such an extent that only a very small fraction of one fills the entire 4 x 4-in. screen. By shifting the commutator brush and adjusting *R*, any small part of the diagram can be made to cover the whole screen for detailed study.

Use of the one-stage amplifier makes it necessary to calibrate the apparatus several times each day. This is done by connecting the indicator to the calibration apparatus previously described and plotting spot deflections against pressures.

This circuit has proved very stable and easy to use. It is assembled in two cases, as shown in Fig. 23. One case contains the Wheatstone-bridge circuit and extra space in which to pack the cathode-ray tube while the apparatus is being transported. The other case contains the B-batteries, tube mountings, and control rheostats. The batteries are the lightest-duty radio batteries obtainable, because the currents to be drawn from them are very small. A photograph of two cathode-ray oscillograph-tubes is reproduced in Fig. 24.

With this apparatus the diagram remains perfectly synchronized, the only fluctuations being those due to the irregularities of combustion. The observer is not distracted by engine noise and vibration; he is free to study the diagram as if it were a thing apart from the engine.

Limitations Are Being Overcome

The most obvious shortcoming of the indicator in its present stage of development is that no means are provided for taking pressure-volume cards. For fundamental research, the pressure-time cards are probably much to be preferred; but for routine work, pressure-volume cards also are desirable without the trouble of re-plotting. If the demand for pressure-volume cards becomes great enough, some provision may be made for giving the cathode-ray spot a reciprocating motion controlled by the engine. In the case of the mechanical oscillograph, the beam of light from the element will have to be reflected from a second mirror having a reciprocating motion controlled by the engine. In both cases an attempt will be made to attain the result electrically, in such a way that electrical conductors will constitute the only connections to the engine.

Good clear-cut photographic diagrams have not yet been obtained with the cathode-ray oscillograph. For composite diagrams a sharp outline is not so necessary as for individual cards. The trace on the screen appears much finer to the eye than when photographed by direct contact with the film. Just how much improvement can be made in sharpness of line is unknown at present.

The new indicator at present cannot be connected to an engine without drilling and tapping a special hole in the cylinder-head. The design of a unit to serve both as a spark-plug and an indicator is nearly enough complete to make it seem probable that in the near future an engine can be indicated by removing the plug and substituting an indicator plug in its place.

Railway Companies and Road Transport

IN connection with the controversy in England recently regarding the bills for railroad road-transport powers introduced in Parliament, Major Gen. S. S. Long, chairman of the Mansion House Association on Railroad and Canal Traffic, in a statement quoted a departmental committee report of several years ago to the effect that, with reference to traffic which has been diverted from the railways to the roads by means of independent road carriers, that traffic in no sense belongs to the railway companies but is the legitimate extension of the business of the old road-haulage contractor. It is ancient history, the report continued, that the railways, by reason of the great facilities they afforded, have diverted traffic from stagecoaches and other horse-drawn road-vehicles, and from canals... and the railway companies are only suffering in their turn from what happened to the stagecoach proprietor, the road-haulage contractor, and the companies owning canals. In the view of the committee, it was further said, only those are entitled to traffic who can carry it in the best and the cheapest way, and, therefore, the committee was not prepared to recommend that a railway company should begin, under an Act of Parliament, an entirely new trade; it is satisfied that competition between independent road-haulers and the railway companies has resulted in public benefit.

Foreign Competition

MOST of the countries of Western Europe are now steadily increasing their industrial efficiency. A marked expansion of agriculture is taking place in areas where there is much virgin land, notably Argentina and the wheat regions of Canada. In Germany and elsewhere in Western Europe, agricultural improvement goes on, the chief gains being approach to normal conditions in the animal industries. A wave of mineral exploitation is in progress in many places, partly the result of improved technique in methods of locating mineral bodies and in their utilization.

Our foreign trade continues in large volume, exports for 1927 being somewhat larger than in 1926 and imports a little less, but it is clear that in the future increasing competition will be encountered by American exporters, whether of finished manufactures, farm products or minerals. There is every indication that our enterprise will enable us to meet this competition successfully, but, if so, our fitness to do so will have had its origin in no small part in the severity of domestic competition, which leaves no alternative but efficiency.—J. S. Alexander, National Bank of Commerce in New York.

Progress in Military Transport

By W. F. Rockwell[1]

Milwaukee Section Paper — *Illustrated with* Photographs

OUTLINING the history of the early efforts of the American Army with motorized transportation, the author mentions the Army motor-truck specification of 1916 in the preparation of which a committee of the Society cooperated. The punitive expedition into Mexico provided invaluable experiences in preparation for the World War.

Transportation for the Army is in charge of the Quartermaster Corps and the head of the transportation service now is Brigadier-General Pope. The Corps has charge of the design and procurement of all vehicles excepting specialized vehicles of the Ordnance Department and special equipment for technical purposes.

The needs of the Army range from conventional passenger-cars and motor-trucks to highly specialized vehicles. One of the requirements of many of the vehicles is the ability to travel over poor roads and across fields, and it is important that during the last few years, vehicles have been developed that will meet this requirement without great sacrifice in speed over good roads.

Mention is made of the significant fact that much of the motorized equipment of the Army was purchased during the war. Progress in military investigation is delayed by lack of appropriations. To safeguard the Country against military domination, the Constitution, laws and regulations provide that the Army be directed by civilians and that Army officers cannot organize propaganda for appropriations. For this reason, any pressure upon Congress for the appropriations needed for developing motorized transportation must come from citizens.

An outline is presented of plans for Army maneuvers during the summer of 1928, when extensive tests of motorized transportation will be made.

The discussion of the paper is chiefly in regard to the development of transports for Army work in multiple-wheel-drive vehicles, with the resulting problems of bogie truck, emergency tractor-tread, and tires. The newer types of motor-truck, with greater power and a greater range of speed-reduction, are said to meet the needs of the Army much better than the trucks that were used several years ago.

MILITARY motor transportation in connection with the War Department began its history at Camp Jossman Guimaris, P. I., when a traction engine with two trailers, supplemented by a heavy wagon drawn behind the trailer, was procured and used successfully in hauling supplies from the quartermaster dock at Buena Vista to the camp, a distance of 4½ miles with a climb of 450 ft. There are records of a test of 1½-ton trucks at West Point as early as 1904. While this test demonstrated that the truck would doubtless be of value to the Army in the future, it was not sufficiently successful to create any particular interest at the time.

In 1912, officers of the Quartermaster Corps made a test run with trucks from the City of Washington to Fort Benjamin Harrison, Ind., by way of Atlanta, Ga. Twelve vehicles left Washington and only four arrived at Fort Benjamin Harrison, where final tests and inspection were completed. Another test was made a little later, in a maneuver from Dubuque, Iowa, to Sparta, Wis. The conclusion reached was that motor transportation of the character developed up to that time was not practical or economical for Army use.

In 1914 the Society of Automotive Engineers, having studied the use of motor transportation by European nations then at war, concluded that it was an important development as an aid to present-day warfare and offered its services to the War Department for the purpose of making a complete survey of the automotive industry in the hope that the interests of the Army and the industry could be coordinated so that, in an emergency, the industry might be able to cooperate with the Army in providing such equipment as the service would require.

Pursuant to this offer, but not until 1916, the War Department asked the cooperation of the Society in revising specifications for 1½-ton Army trucks, which were then being seriously considered by the Army. The Society named a committee of engineers of a number of companies manufacturing and assembling motor-trucks. This committee, in conjunction with the Quartermaster Corps, went over the specifications for the 1½ and 3-ton trucks, and, after making a few changes, the specifications were drawn up for what then seemed to be the ideal trucks for Army use.

Just at this time the punitive expedition was ordered into Mexico. Extensive use was made of motor-vehicles

[1] M.S.A.E.—President, Pittsburgh Equitable Meter Co., Pittsburgh, and Wisconsin Parts Co., Oshkosh, Wis.; Major, Quartermaster Reserve Corps.

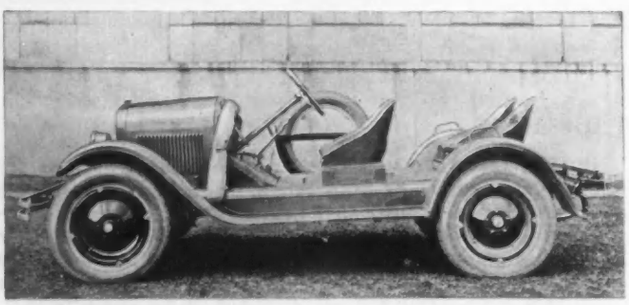


FIG. 1—AN IMPROVISED CROSS-COUNTRY CAR

The Chassis of a Light Passenger-Car Is Stripped and Equipped with Extra Large Tires and Bucket Seats. The Light Weight and Large Tire-Surface Enable It To Do Cross-Country Work

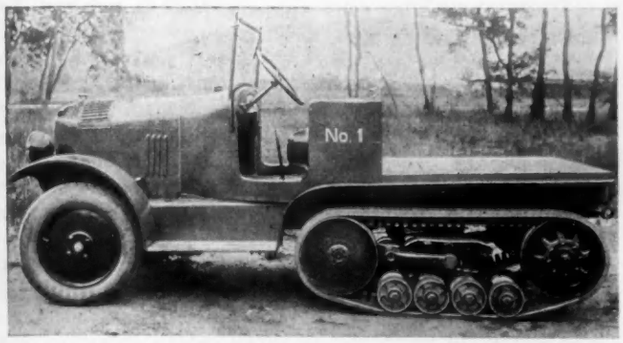


FIG. 2—CITROEN 16-HP. DESERT CAR

during that expedition, and the experience gained was invaluable in the greater conflict that was to come.

THE QUARTERMASTER CORPS DIRECTS TRANSPORTATION

Under the present Army organization, the Quartermaster Corps, whose detailed functions and duties it is unnecessary to dwell upon, is divided into three major services—supply, transportation, and construction—each under charge of a general officer, assistant to the Quartermaster General. To these may be added other services, such as the remount and personnel.

The transportation service contains four divisions, animal, motor, rail, and water, which function more or less independently but whose direction is coordinated under the chief of the transportation service.

Brigadier-Gen. F. H. Pope, Q. M. C., who is now chief of the transportation service and has had many years of actual contact and experience with Army transportation-problems, was in charge of one of the first major fleets of motor-trucks put into service during the Mexican trouble. His comments on Army transportation[2] make a very comprehensive survey of the general scheme of Army motor-transportation, so that it is unnecessary to go into general plans at this time.

It should be understood that the responsibility of the Quartermaster Corps with respect to transportation of the Army is fixed by law in the National Defense Act, as amended to include March 4, 1927, which provides:

> The Quartermaster General, under the authority of the Secretary of War, shall be charged .... with the transportation of the Army by land and water, including the transportation of troops and supplies by mechanical or animal means; with the furnishing of means of transportation of all classes and kinds required by the Army; ....

In accordance with the plan, the Quartermaster Corps has charge of design, specifications, procurement and supply of wheeled motor-vehicles, including passenger-cars, motor-trucks, trailers, motorcycles, bicycles, and special vehicles for transportation of men, munitions, horses, special equipment, and supplies of all kinds that need to be transported over highways or across country.

THE ORDNANCE DEPARTMENT NEEDS ARE SEPARATE

The foregoing should not be confused with the design, procurement, supply and operation of vehicles or tractors of the track-laying type for which the Ordnance Department is responsible, including tanks, tractors, and vehicles for hauling or towing artillery guns, ammunition and reel carts.

This accounts for all automotive equipment used or required by the Army. Special vehicles—such as searchlight power-units, radio, telephone and telegraph, balloon winch, air-compressor, dental laboratory, blueprinting, power saw, machine-shop, and a number of others—are classed under the general heading of technical vehicles, and the design, development, procurement and supply of the chassis remains with the Quartermaster Corps; but the design, development, procurement and supply of the special bodies and equipment, and usually the maintenance and repair, are left in the hands of the service which makes use of the vehicle. Under the general scheme of motor transportation, these technical vehicles will use standardized chassis if possible, with standardized units such as axles, transmissions, steering-gears and engines when it is necessary or desirable to provide chassis differing in wheelbase or with other modifications of the standard chassis.

WIDE RANGE OF VEHICLES NEEDED

It will be seen that the requirements in automotive vehicles run all the way from conventional passenger-cars and motor-trucks to very special technical vehicles. The development of better passenger-vehicles and of rear-wheel-drive conventional trucks can be left safely in the hands of private manufacturers. In this phase of the motor-transport problem the Army has little to do except to keep in touch with the progress of the automotive industry.

Passenger-car requirements in their next stage call for some degree of armored protection, with various requirements up to a thoroughly armored passenger-vehicle with protection for radiators, gasoline tanks and passengers and with puncture-proof tires. The Quartermaster Corps is not working on this problem now because no funds are provided. There also are requirements for cross-country reconnaisance-cars and cars with tractor attachments, such as the Renault and Citroen that have been developed in France for desert work. As there is very little commercial demand for such vehicles, the Motor Transport Division has to carry on this work. At present, observation and study of foreign developments are the only means available. A cross-country car, made by remodelling a light passenger-car, is shown in Fig. 1, and a Citroen desert car in Fig. 2.

Careful study of war requirements for motor trans-

FIG. 3—WARTIME F. W. D. TRUCK

[2] See THE JOURNAL, December, 1927, p. 660.

FIG. 4—MILITOR TRUCK IN A MUDHOLE
This Vehicle Was Designed during the War. Like Other Trucks of the Period, the Power, Gear Ratio and Tire Equipment Were Not Such As To Provide the Ability Necessary for Extreme Conditions

port shows that approximately 50,000 four-wheel-drive vehicles would be required for a general mobilization. The Motor Transport Division has built several special four-wheel-drive vehicles and has purchased a number that are privately manufactured. Several manufacturers have loaned such vehicles, and the Division is always willing to test out any new vehicle of this sort. These tests have proceeded far enough so that the Quartermaster Corps is in a position to recommend the purchase of certain four-wheel-drive vehicles in case of an emergency, and there are several available suppliers. The use of standard parts in these vehicles makes it possible to have them built by any motor-truck manufacturer within a relatively short time. Less than 1000 four-wheel-drive vehicles were produced in this Country during 1927, so that war requirements would present a real problem.

DEVELOPMENT OF SIX-WHEEL VEHICLES

Our Army officers are kept informed of foreign developments through our military attaches. The British Army has developed a six-wheel vehicle in which there are two rear-axles made up into a bogie, or four-wheel-drive under-truck, and a number of private manufacturers in England are building six-wheel vehicles which meet the British Army requirements. The British Government has provided a subsidy so that purchasers of these trucks for private use are given annual payments, in return for which they agree to turn these vehicles over to the army in case of emergency. In this Country we have no such subsidy, but the six-wheel vehicle is coming into use and several truck manufacturers are turning them out commercially. The Army has several of these vehicles under test.

The Motor Transport Division has carefully followed European multi-wheel developments and has built several special six-wheel vehicles at Camp Holabird, Baltimore, Md., but if private manufacturers develop suitable six-wheel vehicles for commercial service the Army will gladly use them.

Our own Ordnance Department and the British War Department have shown great interest in six-wheel vehicles, and hope to develop special tracks of rubber, leather, or other materials to go over and around the wheels to provide tractor performance for off-road work. Such vehicles could travel at high speed on good roads and could approach tractor performance across country with the tractor adaptors in place. More powerful engines and heavier wide-range transmissions must be provided in such vehicles for these extra off-road stresses and strains.

DRIVING OF SIX WHEELS

The Motor Transport Division has built a special six-wheel-drive vehicle in which many of the parts of the front axle are interchangeable with those of the two rear-axles. Differentials, drive gears, wheel bearings and axle shafts are the same, simplifying the problem of service and replacement.

A six-wheel gasoline-electric-drive vehicle has been developed by the Quartermaster Corps and built at Camp Holabird, in which there is an individual electric-motor drive for each of the three axles, providing six drive-wheels. It has been possible to use the same axles for this gasoline-electric drive as are used for the mechanical four-wheel-drive vehicles, although a different axle-ratio was required. There are some very interesting possibilities in these vehicles, particularly with reference to standardization.

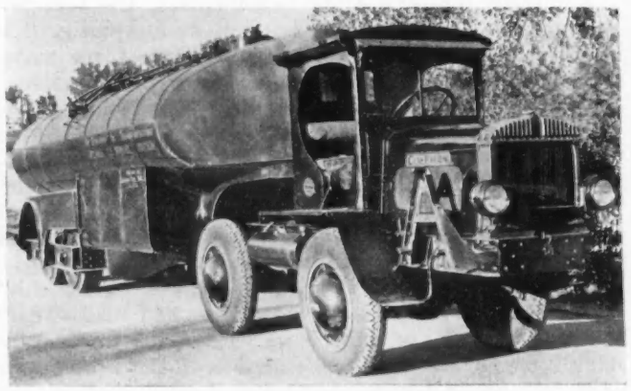


FIG. 5—MODERN FOUR-WHEEL-DRIVE TRACTOR WITH TANK TRAILER

The large number of vehicles for technical purposes which require electric current make the gasoline-electric drive desirable, even though it may not be entirely satisfactory or economical for commercial use. The Army has two possibilities in these technical trucks: first, the gasoline-electric drive in which the electric current is used to motor-drive the axles for transportation and the electric current is available for the technical apparatus, such as motor-driven machine-tools, searchlights, and so on; and, second, the gasoline-engine-powered vehicle in which the power is delivered to the wheels mechanically, but with an arrangement to drive an electric generator from the engine when the vehicle is stationary. The Army has a searchlight vehicle on a Cadillac chassis, in which the eight-cylinder engine drives a generator to provide current for the searchlight when the vehicle is stationary. If the gasoline-electric truck proves satisfactory, there are some very interesting possibilities for the development of better technical apparatus for use in the field.

MULTI-WHEEL DRIVES COMPLETE WITH TRACTORS

During the World War four-wheel-drive trucks were available, but their field of operation was not very great because they had relatively small powerplants, three-speed transmissions, and axle ratios with relatively small reductions. They were equipped with narrow solid-tires so that they had little ability to operate

off the roads. If several of these vehicles attempted to cross soft ground, each vehicle that passed made the surface less negotiable for those following. A few of the old war-time trucks are still in use, but they are practically obsolete now. Some of them are shown in Figs. 3 and 4.

Four-wheel-drive vehicles now are available with large and powerful four or six-cylinder engines, dual transmissions combined with heavy axles to provide total reductions as great as 200 to 1, and with very large balloon-type tires. This type of four-wheel-drive truck can operate at high speed and has exceptional ability to cross fields, as the large tires provide excellent adhesion, making effective the use of the great tractive-effort available. The high torque-weight ratio has brought these vehicles into direct competition with the tractors. In some cases these four-wheel-drive and six-wheel vehicles will undoubtedly replace tractors for hauling guns and for other heavy-duty requirements. Under some conditions, the large pneumatic-tires on these trucks will run over soft ground and make it less difficult for the vehicles following.

The four-wheel-drive vehicles of the present day often will carry a full load through places which the four-wheel-drive vehicle of 10 years ago would not negotiate without load. Special transmissions make it possible for these trucks to accompany marching troops without overheating the engines, and the use of six-cylinder engines has widened the speed-range. The four-wheel drive and the multi-stepped transmission make it possible for these trucks to descend long steep grades without the use of brakes. In every conceivable way they perform work which rear-wheel-drive trucks cannot do, and which tractors cannot do because of their speed limitations. One special four-wheel-drive vehicle weighing 21,000 lb. has developed a drawbar pull of over 12,000 lb., which is considered as equalling tractor performance. Fig. 5 shows one of the modern four-wheel-drive tractors with a heavy semi-trailer. In Figs. 6 and 7 one of the newer trucks is seen under test. Fig. 8 illustrates the necessity of avoiding excessive overhang at the front of the chassis.

Future Warfare Hinges on Transportation

Some military experts believe that future wars between the great powers will be entirely different from anything in the past, and that wars will be won by the army which employs the greatest number of fast-moving units on land and in the air. If we assume that long-range artillery can be camouflaged sufficiently to prevent discovery by enemy airplanes and can be directed in gunfire by observation airplanes, and if airplanes are available in large numbers which can use demolition bombs, gas bombs and machine guns, it seems that these would make fortifications untenable and any massing of large numbers of troops suicidal. Under these premises, fortifications or masses of troops could not survive against airplanes and long-range guns, so that the airplane and rapidly moving vehicle with relatively light gun-equipment, very mobile and able to negotiate country without roads, would become the weapons for both defense and offense.

From the foregoing remarks it will be seen that the Army is constantly studying to provide better methods of motor transport.

The conventional types of passenger-cars, motor-trucks, and tractors are being commercially used and improved by private interests, and no one desires to see the Army involved in heavy expenditures for experimental purposes in these directions.

Fig. 6—Modern Four-Wheel-Drive Truck Under Test

The Men in This Illustration Are the Author and A. W. S. Herrington, Both of Whom Are Officers in the Quartermaster Reserve Corps

As we proceed to the many technical requirements of the Army we find less and less opportunity to depend upon private enterprise. The high-speed armored passenger-vehicle and the four-wheel-drive and six-wheel cargo-carrying and trailer-hauling vehicle are finding some commercial applications, but the Army undoubtedly will have to spend money to develop special cargo carriers to meet extreme conditions. The Ordnance Department has the most serious problem in the development of light high-speed tractors, which have very little commercial application, and the very heavy tank-chassis tractors, for which there is no commercial use and almost no precedent in design. If future wars are to be fought with high-speed units in the air and on the land the value of such heavy tanks is very doubtful, but certainly experiments should be carried along.

Motor Transport Will Be Essential

In European countries the special preparations for future war seem to be concentrated in the development of airplanes and in the building of complete net-works of military roads. If the air offense is very formidable, the defense will have to provide airplanes and rapidly moving motor-vehicles equipped with anti-aircraft guns. Railroads can be put out of commission completely by blowing up bridges and bombing tracks. Highways also can be put out of commission by the same method, but, if motor vehicles are provided which can travel at high speed on the roads and still have the ability to traverse off-road areas, motor transport will be much more reliable than rail transport under the same conditions of air attack.

There has been occasional criticism of the Army for failure to develop special trucks, and there have been one or two pointed editorials in automotive trade-papers. The criticism seems to show a lack of understanding of the necessary steps to carry on experimental work for the Army. Many people overlook the fact that the Army and the Navy operate under the direction of civilians, the Secretary of War and the Secretary of the Navy, who answer to the President as Commander-in-Chief of our military establishment; Army officers are not in supreme command. The President and the two Secretaries have very limited power during peace times, inasmuch as appropriations are almost entirely in the hands of Congress.

Freedom of speech and freedom of the press make it possible for almost anyone to criticize the War-Department program. Officers of the Army and Navy are permitted to present ideas for the betterment of the service, but they are not allowed to criticize. Furthermore, it is forbidden for officers to organize for the purpose of swaying public opinion, and they are not permitted to approach Congress in efforts to obtain appropriations for their departments, except through regular channels which eliminate any possibility of organized propaganda. This is all in accordance with the Constitution of this Country, which aims to keep all military matters in the hands of citizens and to avoid the formation of any military parties with militaristic ambitions.

Not long ago the Secretary of the Navy asked Congress for authority to construct a number of ships to carry out a big program. In view of the fact that certain international agreements might hinge upon future naval construction, the Secretary asked Congress to give the President the authority to stop the building program at his discretion, which Congress has so far refused to do.

Educational Contracts for Munitions

Secretary Davis has presented a plan to Congress for letting contracts to private manufacturers for producing various kinds of munitions. His plan is to give out these contracts to private manufacturers who may thus obtain information and experience so that, in case of war, their plants can arrange to turn out guns and ammunition in a very short time, without confusion. In other countries such plans can be carried through without disclosure or reference to legislative bodies, but we require specific Congressional approval. The plan has the backing of General Pershing, who says[1]:

> In my opinion, provision for educational contracts would be a very desirable step toward the organization of industry for the benefit of National defense. In accordance with the present law, the very limited peace-time production of munitions must be accomplished in Government arsenals. These, however, would be able to manufacture only a small fraction of all munitions required in any extensive campaign. The proposed authorization would make it possible to give industrial establishments some limited experience as a basis for the perfection of plans essential to their full cooperation in the event of another great emergency.

These illustrations are presented to show that Army policies and plans are almost entirely subject to Congressional approval, and that we cannot build special trucks or tractors without obtaining sanction and essential appropriations from Congress. Everyone connected with the automotive industry must consider himself responsible for the progress of automobile activities in the Army. If the industry feels that more experimenting should be done, it must make its appeal to Congress, as it is quite useless to blame Army officers if the appropriations do not cover the requirements. The will, the energy, the ambition to carry on experiments, and the ability to design special automotive vehicles will be found in the present group of officers who have charge of the automotive sections in the Army.

How the Budget System Operates

Under the present Government budget-system each branch of the service makes up its own budget requirements, which are passed along through the General Staff, the Secretary, the Director of the Budget, and then to Congress. It is very seldom that anyone along this route tries to increase expenditures under the present reign of economy, which is justly popular. In many cases the Congressional committees have voluntarily increased Army appropriations, and there is little to complain of in the attitude of Congress. If the authority were entirely in the hands of the Army, large amounts of money might be wasted on experiments of little value, so this system is reasonably satisfactory. If the results in military motor-transport are not satisfactory at present, then the automotive industry should be aware of it and should sponsor a movement for larger appropriations.

The remote possibility of war at present has a tendency to make us forget the future, but it is obvious that special devices which require years of study and trial could not be perfected in a few days if a national emergency should arise.

[1] See *The Literary Digest*, Jan. 14, 1928, p. 12.

If there is sufficient commercial demand, private enterprise can be depended upon to make progress, so that, in various fields of commercial passenger and truck transportation, private enterprise is now doing more than the Army could hope to do if it had unlimited appropriations. There are, however, certain fields in which private enterprise will enter very slowly, although there are known to be profitable possibilities after the preliminary steps have been covered. Our airplane industry would not be in its present thriving condition but for the military interest and the Post-Office support which brought about the remarkable achievements that have made commercial progress possible. The money spent by the Government in this work has been returned to the Country by the general progress in this industry, and from now on private enterprise will carry a large part of the burden of experimental work.

Military Developments with Commercial Uses

The progress in four-wheel-drive-truck design was greatly stimulated by the war; and further development work in both the four-wheel-drive and six-wheel vehicle may profitably be carried on by the Government, as it will undoubtedly lead to further use in commercial enterprise. Mines in the Rocky Mountains, which were inaccessible and were forced to close down during the winter period, now are operating because four-wheel-drive vehicles have solved their transportation problem. Four-wheel-drive vehicles are being used extensively in the oil fields, and, owing to the lack of transportation in some of the newly discovered fields, they will be used more extensively.

The French Army has carried on experiments to develop vehicles to traverse long desert expanses, and its work may result in opening up desert areas which formerly had no commercial value. The Italian Government has been working on tractors for use on mountain trails and in extreme conditions of cold over snow and ice. We have nearly every condition of nature in our own Country, and the Army should develop vehicles to meet all conditions of temperature, weather, and terrain. In connection with this work, it is necessary to develop accessories, such as dust filters, exhaust heaters, semi-pneumatic tires, skid chains, half-track attachments, and so on. While appropriations necessary to cover such work may seem to be largely wasted, the past has shown that most military inventions have been applicable to civil life. Even in the field of high explosives, military developments have proved of great value to the Country at large in mining, agriculture, and other industries.

[4] See *The Military Engineer*, January-February, 1928, p. 7.
[5] See THE JOURNAL, November, 1927, p. 539.

FIG. 7—FOUR-WHEEL-DRIVE TRUCK PULLING THROUGH SAND

FIG. 8—FOUR-WHEEL-DRIVE TRUCK ON ROUGH GROUND.
Excessive Overhang of the Engine and Radiator May Cause a Truck To Stall Where It Otherwise Could Go Through

Plans for Automotive Cooperation

Major L. H. Campbell has stated clearly how the various Automotive sections of the Army cooperate with private manufacturers. He says[4]:

> Each year, the Department tests out a few models of commercial track-laying-type tractors with a view to keeping abreast of the progress of the industry and of acquiring knowledge as to which of the commercial tractors will most nearly meet Army requirements. In such consideration, due weight is given to the production facilities of the companies manufacturing the vehicles.

The Quartermaster Corps is carrying on the same kind of work with automotive manufacturers. It also is providing a splendid training-course for Army mechanics and maintains model shops at Camp Holabird and Camp Normoyle. The Army system of maintenance has been outlined well by Capt. Walter C. Thee[5].

The War Department is planning to constitute an experimental mechanized force of regular Army units at Camp Meade, Md., during the summer of 1928, under the direction of the Commanding General, Third Corps Area. This indicates the interest of the War Department in the motorization of the Army and in overcoming all obstacles to motorization at the earliest practicable date.

The exact purpose of this concentration and demonstration, as stated by the War Department, is to "develop and test its tactical and strategical employments and for study and test of the organization and equip-

ment for the motorization and mechanization of appropriate units of the Army." Notwithstanding the fact that no present appropriations are available for the procurement of modern motor-equipment, except for a small number of passenger-carrying vehicles, and despite the likelihood of any funds becoming available for this purpose before the fiscal year of 1930, it is contemplated that this force, as far as is practical, shall be "equipped with transportation and motor-vehicles of the latest approved design."

Vehicles Required for Maneuvers

In equipping the mechanized force, all suitable trucks and motor-vehicles of the latest approved design required by this force, now held by the Quartermaster Corps and the Ordnance Department and in use in the field, will be made available for this test. It is proposed that manufacturers of motor-vehicles of possible use by mechanized and motorized units of the Army shall be invited to submit their most modern trucks and other motor-vehicles for test by the mechanized force, so that the War Department can gain information as to the types most suitable for Army use.

The types of vehicle that will be required include: Cross-country passenger-cars; cross-country trucks; light motor-trucks; medium motor-trucks, ¾ to 1¼-ton; 3 to 5-ton two-wheel-drive trucks; 1½ to 5-ton four-wheel-drive trucks; 5-ton six-wheel trucks; 750-gal. tank trucks for gasoline and oil; 2½-ton track-laying tractors; 5-ton track-laying tractors; ¾-ton light-repair trucks; motorcycles with side-cars; reel and cart trailers; kitchen trailers; water trailers; cargo carts; power carts; bicycles; and other vehicles that may be selected as suited to the requirements of the various units that will participate. The track-laying-type vehicles, power carts and cargo carts will be furnished by the Ordnance Department. The Commanding Officer at Camp Holabird was designated to select and make ready for this test the motor-vehicles that will be required, insofar as they are available, and to confer with manufacturers desiring to have their product represented in this demonstration.

The Motor-Transport School at Camp Holabird will be made available for training officers and enlisted men of the mechanized force, and this training will be augmented by the establishment of motor schools at the stations of the units concerned. Realizing the extreme importance that the results of this test will bear to future mechanization of the Army, it is planned to assign several experienced Motor-Transport officers from Camp Holabird to assist in securing the maximum results. Special attention will be given to the use of the best approved methods of operation and loading, convoy practice, traffic control, daily inspection and servicing, and field repairs. The feature of maintenance and field repairs in connection with the mechanized force is of extreme importance also, and it is planned that the burden for the maintenance and repairs in accordance with the unit-repair system shall fall on a motor-repair section, based on Camp Holabird.

An Important Test of Motorized Transportation

That the purpose of this test may be fully understood and the most suitable motor transportation procured or made available, the Directive states: "Its operation will include work over terrain sufficiently varied and difficult, and under such conditions of weather as will determine the powers and limitations of motor-vehicles and mechanical transportation as compared with animal and animal-drawn transportation operating under similar conditions."

An interesting feature of the program is the provision to "port" three rifle companies, each consisting of 9 officers and 246 enlisted men, with individual equipment consisting of packs and tents, and company equipment. For each company will be required three cross-country cars—or five-passenger automobiles as a substitute—and eight 3 to 5-ton trucks, each truck to carry 30 men with individual equipment. Emphasis has been placed on the desirability of securing for this test motor-vehicles of the latest approved design, but if these cannot be provided available equipment will be utilized.

In connection with this feature of the plan, it is proposed to modernize a small number of the Army 3-ton four-wheel-drive trucks by providing important engine improvements, low gear-reduction, improved carbureter and manifolding, improved bevel-type differentials, improved axles, new-type universal-joints, improved double truss-rods, high-pressure chassis-lubrication, pneumatic tires, and other improvements that increase the mobility and serviceability of these vehicles. Organizations participating will be: One battalion of infantry; one tank platoon; one battalion of field artillery, less one battery; one anti-aircraft battery; one engineer combat company; one signal company; one ammunition train (motor elements) and a medical detachment. A complete report will be submitted upon the completion of the test.

Those who are interested in the British developments are referred to an article by Capt. C. H. Kuhne[6].

Regarding our own progress in military transport, investigation will show that we have competent officers in charge of the automotive work in the Army, and that they are making splendid use of the appropriations provided. It is the patriotic duty of the members of the Society of Automotive Engineers to keep in touch with military affairs, and if you believe that more money should be spent for experimental work you should bring the matter to the attention of your Representatives in Congress.

THE DISCUSSION

Chairman Cyrus L. Cole[7]:—One of the surprising things brought out by Mr. Rockwell is the replacement of the track-laying tractors with four-wheel-drive trucks. Is there any definite limit to that?

W. F. Rockwell:—It is hard to say, but the tractors are quite limited in the distances they can cover and are very expensive to operate. If we come to high-speed warfare they will have almost no place at all. One of the 5-ton four-wheel-drive vehicles, weighing 21,000 lb., has developed a drawbar pull of more than 12,000 lb. The pull compares very favorably with that of the 12-ton tractor. It certainly seems to eliminate the light tractor.

If the type of warfare of the last war were to prevail, the small, or whippet, type of tractor would have to be used against machine-gun nests; but, according to the present plans, they would have to be brought up to the front on trucks with winches, just as the cavalry is finding that it must carry horses to the point where they can be used when they are needed.

[6] See *The Automobile Engineer*, December, 1927, p. 506.

[7] M.S.A.E.—Vice-president and engineer, Williams, Cole & Wolff, Inc., Milwaukee.

I think most military experts doubt whether anything heavier than the 12-ton tractor will ever be used. It is doubtful if 100 tractors of over 20 tons ever have been built, and anything in the way of self-laying track for a vehicle of that weight is almost entirely experimental at this time. With the limited appropriations they will probably be experimental in this Country for many years to come, although we undoubtedly will know something about it if they are developed abroad.

QUESTION:—Has the Army tested the Relay drive?

MR. ROCKWELL:—A Relay truck was sent to Camp Holabird, but it was not submitted for test. It might be barred from Army work on account of its low clearance, and the arrangement of the rear axle might cause trouble with the universal-joints. At present, universal-joints are in poor favor with the Army, and the troubles they have had with them probably would make it difficult to obtain approval for a job that has universal-joints working at extreme angles. Of course, universal-joints can be made better and bigger, and probably they will be so made if the requirements are insistent enough.

DE WITT CLAUSEN[8]:—Which type of drive is best for front axles, the knuckle pinion with bevel gears, or the universal-jointed shaft?

MR. ROCKWELL:—Nothing I could say would aid in settling that. The Army is not particularly interested in the most efficient type of drive so long as it does not interfere with the more important requirements. The worm drive cannot be used, because the overhead worm would bring the engine too high and the underslung worm would allow too little road clearance.

How To Have a Truck Tested

A. C. WOLLENSAK[9]:—What is the procedure to have a truck entered for Government tests, and what is the nature of the tests?

MR. ROCKWELL:—If you will write to Brigadier-General Pope, or anyone in the Quartermaster Corps, he will be very glad to tell you what is necessary, or Col. E. S. Stayer, the commanding officer at Camp Holabird, will give you the information. Anybody connected with the Army will be glad to tell you how to enter trucks in the test.

Camp Meade is a 20,000-acre reservation with many possibilities in the way of terrain. There are long trails, swamps and mud, many difficult cross-country paths, stone surfaces, and roads of various kinds with all degrees of grade. The units will be tested in every way possible, and after the Corps is through with a truck it surely will be a second-hand vehicle. If there are any little weaknesses, such as in the universal-joints, you will know about them. Everything in the way of motor-vehicles will be tested there, including motorcycles.

The British Army has developed a motorcycle, with a track running over two wheels at the rear, which they claim is good, but the experience of the American Army at Camp Meade does not coincide with that of the British.

The tests at Camp Meade will be open to any interested automotive manufacturers, and probably to the public. The order clearly states that anyone who provides equipment can be on hand to watch the demonstration.

Anticipate the Wartime Rush

L. M. KANTERS[10]:—Ordinarily it takes from 6 to 8 weeks to build an engine after the prints are released. Within 11 days after we received the Class-B motor-truck prints, our organization had the engine running. I believe one of the other companies did it in 9 days. I remember that one of our men had to bring a crankshaft home in the berth of a Pullman in order to accomplish that.

MR. ROCKWELL:—All of those things can be done, but much of the argument the Army has now is, why do it that way when it is possible to do it slowly and surely? Let us hove something fully developed and avoid all that additional expense, including carrying crankshafts in lower berths.

MR. KANTERS:—What speed is expected from trucks such as you describe?

MR. ROCKWELL:—That depends upon the requirements. Some of these jobs are being run as fast as 50 m.p.h. For cross-country work they run at a much slower speed, but they have a much wider speed-range than formerly because of the use of six-cylinder engines.

C. S. RICKER[11]:—How much farther from the front can forces be placed with these higher-speed trucks, compared with what was done during the World War?

MR. ROCKWELL:—The Army has had no money for some time to spend on extensive maneuvers. Most of the figures as to that are theoretical, and I would not try to answer that.

CHAIRMAN COLE:—What about the tendency to adopt the six-cylinder engine in place of the four-cylinder?

MR. ROCKWELL:—The Government is leaving it largely to the manufacturers to develop both passenger-cars and motor-trucks, and the development in trucks certainly has been toward six-cylinder jobs. I believe at the New York Show this year there were only two trucks exhibited without six-cylinder engines. One was the Chevrolet and the other was the Pack-Age Car.

Newer Trucks Better for Army Needs

Compared to the truck of 10 years ago, the truck of today has the six-cylinder engine in the larger sizes, additional steps in the transmission, larger tires, and many other things that the Army is very glad to find available. It is doubtful if very many four-cylinder trucks will be built this year, on the basis of number of models. Of course, Ford and Chevrolet make only four-cylinder trucks, and they probably will make 80 per cent of the trucks built. In the heavier trucks, I think that at least 65 per cent of the 2½-ton trucks have six cylinders.

MR. CLAUSEN:—Is anything being done with steam power?

MR. ROCKWELL:—At least one large company is experimenting with steam tractors and steam trucks, but the Army is doing nothing of that sort because it has no money to experiment with anything like that, even if the Quartermaster Corps thought it was a good idea. There are many more important phases to be investigated in Motor Transport. The tendency right now is to leave all such radical developments to private manufacturers. It is only common sense to say that a handful of Army officers should not ask appropriations to design a steam tractor, if large motor-truck manufacturers cannot see their way to develop one. The Army has less

[8] Jun. S.A.E.—Designer, A. O. Smith Corporation, Milwaukee.

[9] M.S.A.E.—Chief engineer, Sterling Motor Truck Co., Milwaukee.

[10] M.S.A.E.—Chief draftsman, Waukesha Motor Co., Waukesha, Wis.

[11] M.S.A.E.—Vice-president, Day-Nite, Inc., Waukesha, Wis.

money to spend and certainly has less expert counsel than the big manufacturers have. It is not financed even to do the simple things along experimental lines, so that anything as complicated as that is not likely to be tried.

Problems of the Six-Wheel Vehicle

MR. RICKER:—What is the purpose of the gasoline-electric vehicle, in view of the greater cost and weight?

MR. ROCKWELL:—Among other things, the current will be available for use for X-ray, telegraph, telephone, motor-driven machine-tools for field repair work, and other field requirements. It is thought also that a six-wheel electric-drive with three motors can be made to approach tractor performance on bad roads and still be capable of high speed on good roads. It eliminates any difficulties with the mechanical transmission and also the great trouble involved in linking the two rear-axles together, as is necessary with all other types of six-wheel vehicles, which require universal-joints, ball joints and aligning members that add weight and are sources of trouble.

All of the development work in connection with six-wheel jobs has been in the method of linking the two rear-axles together. The electric motor is simply hung in a cradle with the rear axles and there is no necessary spring relation between the two axles, as when they are driven from the same source.

R. E. PLIMPTON[12]:—Has the British Government done anything along that line?

MR. ROCKWELL:—No; the English are behind us in most of that development work, and have not yet used six-cylinder engines.

MR. PLIMPTON:—Do you know whether they are experimenting as to whether dual or single wheels are best for the rear bogies of convertible vehicle to which emergency tracks are to be applied?

MR. ROCKWELL:—The English have what they consider to be a satisfactory tractor-truck with which they use dual tires. The track is centered by means of V-blocks, which also help to provide friction to keep the track belt rotating with the rear wheels. They have not completely developed a track for single rear tires, but they have something which they hope will be satisfactory.

Desert Experience in Asia

MR. PLIMPTON:—The Six-Wheel Co. recently turned out a motorcoach with dual wheels. Most of their coaches have single rear-wheels.

Capt. Norman Nairn, whom I met when he was in this Country two or three years ago, had been operating a transportation route from Damascus, about 650 or 700 miles across Turkey and Persia, to Bagdad, making the distance in about 18 hr. at a scheduled speed of almost 40 m.p.h. He used Cadillacs and other high-grade American passenger-cars at first, but he had a very business-like idea of using six-wheel motorcoaches with wide treads. He had to make his own roads, and he found everyone else with a standard tread also used them. He planned, by using the wide tread, to prevent some of the use by other people. He found that there were certain kinds of road that he could not get over with the standard six-wheel type, so he was planning to use duals and carry tracks in the vehicles to put on when they came to one of these bad spots.

QUESTION:—Has the Army done anything in the field of the high-speed Diesel engine, or has it been left entirely to the manufacturer to make further experiments along this line?

MR. ROCKWELL:—The Army has left all such things to manufacturers. There is no money to do anything more than to get the literature on the subject and read about it. The Army men certainly do that. The American Army cannot carry on secret experiments. Congress must be told what the money is for before it can be obtained.

H. L. DEBBINK[13]:—I had a chance to observe the maneuvers of the Third Field-Artillery Brigade when it was motorized in 1918, and I know that one of the chief objections against the tractors, on the part of the general officers on the board reviewing the maneuvers, was because of the noise of the track in striking the hard pavement, and also in going over the rollers, even on soft roads. It is interesting to learn that the four-wheel-drive and six-wheel-drive pneumatic-tired trucks can do the same work as the tractors and do it faster, without that objectionable noise. However, the tracks never went flat, and pneumatic tires will be subject to that danger under machine-gun fire.

Are there any puncture-proof tires available?

What if a Tire Is Punctured?

MR. ROCKWELL:—The British Government is now making some tire experiments. British officers think that, with the 20-lb. low-pressure tires, it will make little difference if one is punctured. The British Army maneuvers have shown that six-wheel jobs can be handled fairly well even with the tires punctured, and that is one reason for the great interest in the six-wheel job. If one of the large pneumatic tires of a four-wheel chassis is punctured, the vehicle is like a torpedoed boat and is quite useless until the tire is replaced.

All European armies are working on the whole question of tires; but, in this Country, funds are not available to do much.

MR. RICKER:—What sizes of tire are used?

MR. ROCKWELL:—The tires are usually the largest available. Long before balloon tires were available for passenger-cars the Government used airplane tires on cross-country reconnaissance-cars, so they were ahead of passenger-car design in that respect.

One of the complaints of the British against the four-wheel chassis is that the tires have a tendency to leave the road on rough ground. The six-wheel drive eliminates much of that, because the rear bogie has a greater tendency to follow the unevenness of the ground, and they think this is a decided advantage. The British use no differential between the two rear-axles and have the two sets of brakes on the rear axles operated independently. If either set of brakes works, it will act on all four rear-wheels.

[12] M.S.A.E.—Associate editor, *Bus Transportation*, Chicago.

[13] M.S.A.E.—Superintendent of gasoline vehicles, Milwaukee Electric Railway & Light Co., Milwaukee.

Automotive Research

Vibration in Automobile Engines

H. A. Huebotter[1] presents in this article analytical methods for determining the unbalanced inertia force and the tangential effort in a line engine. These methods are thought to be of interest for investigation of the effects of various engine design-features on its vibration characteristics.

An equation for the resultant reciprocating force is set forth and methods of expressing the inertia and fluid-pressure torque are given. The determination of minimum and maximum resultants and the balance of inertia and fluid-pressure torques are other topics dealt with. The results of a series of analyses are incorporated in tabular form.

THE vibrationless automobile, the goal of the engineer and the boast of the advertising manager, is gradually approaching a reality. Correct design in the product and refinements in the manufacturing processes have marked the transition from the bone-racking "horseless carriage" of 25 years ago to the luxurious sedan of today. The effort in the development of the passenger-car powerplant has always been directed toward securing, in a reciprocating engine, the uniform torque and the smooth-running qualities of the steam turbine and the electric motor.

Vibration in the gasoline engine is normally caused by free inertia forces and by variations in the torque. Increasing the number of cylinders renders possible the neutralizing of the inertia forces within the engine and provides more frequent power impulses.

The unbalanced inertia force and the tangential effort are usually determined graphically. The analytical methods presented in this discussion, however, will be found convenient and rapid for investigating the effects of cylinder multiplication, crankshaft speed, reciprocating weight, bore, and stroke upon the vibration characteristics of a line engine.

The axial inertia force of the reciprocating parts in one cylinder may be defined by an equation of the following well-known form:

$$F' = K\ (\cos\theta + a\cos 2\theta + b\cos 4\theta + c\cos 6\theta + d\cos 8\theta + \text{---}) \qquad (1)$$

where θ is the crank angle measured from the head-end dead-center position, and the coefficients K, a, b, c, and so forth, depend upon the engine speed and proportions.

The conventional line-engine crankshaft is symmetrical with respect to the midpoint of its length. Each half comprises C cranks uniformly spaced about the axis of rotation and subtending central angles of $360/c$ deg. The engine has, therefore, $2c$ reciprocating assemblies, each of which conforms to the law expressed by equation (1). The resultant of these $2c$ forces is the vectorial sum of the individual forces, which may be computed by introducing the values of θ which correspond to the phase relations of the cranks. This process is tedious and subject to large errors.

Resultant Reciprocating Force Expressed

A short and accurate expression for the resultant of all the forces may be derived from equation (1). If c denotes the number of crankpin planes about the axis, it can be shown that when the values of F' for all the reciprocating units are added algebraically, every harmonic cancels except those which are multiples of $C\theta$. In a four-cylinder engine, $C = 2$ and the term involving $\cos\theta$ cancels. When $C = 3$, only the harmonics in 6θ, 12θ, and so forth remain, since there are no odd multiples. When $C = 4$, as in the straight-eight engine, the harmonics in 4θ, 8θ, 12θ, and so forth are used. The equation for the resultant reciprocating force then reduces to the following definite form:

$$F = 2C\ [0.0000284\,N^2WR\ (\cos\theta + 0.254\cos 2\theta - 0.410\times 10^{-2}\cos 4\theta + 0.744\times 10^{-4}\cos 6\theta - 1.33\times 10^{-6}\cos 8\theta + 2.35\times 10^{-8}\cos 10\theta - 4.09\times 10^{-10}\cos 12\theta + 7.06\times 10^{-12}\cos 14\theta - \text{---})]\ \text{lb.} \qquad (2)$$

where only the harmonics in multiples of $C\theta$ are used. In this equation

N = the crankshaft speed, in revolutions per minute
W = the reciprocating weight per cylinder, in pounds
R = the radius of the crankpin circle, in inches
θ = the crank angle measured from the head-end dead-center of any cylinder
$2C$ = the total number of cylinders in line, arranged in pairs, as 1 and 6, 2 and 5, 3 and 4 in a six-cylinder engine. If C cylinders in line are assembled with a crankshaft that has C cranks evenly spaced about the axis, the coefficient 2 in equation (2) is omitted.

The coefficients of the trigonometric functions apply only to an engine in which the connecting-rod length is double the stroke, but coefficients can be developed for any rod-stroke ratio. For instance, if the rod is 1.5 times the stroke, the quantity in the parenthesis becomes

$$(\cos\theta + 0.343\cos 2\theta - 0.96\times 10^{-2}\cos 4\theta + 0.288\times 10^{-3}\cos 6\theta - \text{---})$$

and if the ratio is 2.5, the expression is

$$(\cos\theta + 0.202\cos 2\theta - 0.20\times 10^{-2}\cos 4\theta + 0.216\times 10^{-4}\cos 6\theta - \text{---}).$$

Inertia and Fluid-Pressure Torque

Since the inertia force F acts through the connecting-rod, it must exert a tangential force upon the crank. The resulting torque often has an appreciable influence upon the engine vibration. An equation for the resultant inertia torque due to $2C$ reciprocating masses may be derived from equation (2). For a rod-stroke ratio of 2, the inertia torque is as follows:

$$T = 2C\ [0.0000284\,N^2WR^2\ (0.0635\sin\theta - 0.5001\sin 2\theta - 0.1920\sin 3\theta - 0.01612\sin 4\theta + 0.259\times 10^{-2}\sin 5\theta + 0.39\times 10^{-3}\sin 6\theta - 0.44\times 10^{-4}\sin 7\theta - 0.84\times 10^{-5}\sin 8\theta - 0.76\times 10^{-6}\sin 9\theta - \text{----})]\ \text{lb-in.} \qquad (3)$$

[1] M.S.A.E.—Chief Engineer, Butler Mfg. Co., Indianapolis.

The symbols have the same significance as in equation (2), and only harmonics in multiples of $C\theta$ are used.

The resultant fluid-pressure torque at any crank position in a line engine may be expressed in somewhat the same manner as the inertia torque. Assuming that the pressure-volume characteristics of the cycle are similar to those shown in the upper part of Fig. 1, the tangential force at the crank is given in the lower section. This curve, which covers one complete revolution, is a composite tangential-effort diagram for each pair of cylinders whose cranks are in line.

The mathematical expression for the curve in the lower half of Fig. 1 may be written quite accurately as a Fourier Series in functions of multiples of the crank angle θ. For C pairs of cranks, all harmonics cancel except those involving multiples of $C\theta$, whence the resultant fluid torque is given by the following equation.

$$M = \frac{\pi B^2}{4} R C (38 + 30 \cos \theta - 13 \cos 2\theta - 15 \cos 3\theta - 18 \cos 4\theta - 15 \cos 5\theta - 7 \cos 6\theta + 75 \sin \theta + 54 \sin 2\theta + 30 \sin 3\theta + 17 \sin 4\theta + 4 \sin 5\theta). \text{ lb-in.} \quad (4)$$

Only the constant term and the harmonics in multiples of $C\theta$ are valid.

B = the cylinder bore, in inches
C = the number of cylinder pairs
R = half the stroke, in inches
θ = the angle through which the crank has rotated, measured from the head-end dead-center position

The three equations (2), (3), and (4) suffice for the investigation of the resultant reciprocating force, the inertia torque, and the fluid torque of a line engine with cranks uniformly spaced about the crankshaft axis. The effective torque is the sum of the values derived from equations (3) and (4).

Determination of Minimum and Maximum Resultants

The maximum and the minimum resultants are usually of principal interest. In equation (2) the value of F is evidently maximum either positively or negatively when $\cos C\theta = \pm 1$, i.e., when $\theta = 0$ deg., 180 deg./C, 360 deg./C and so on. The angle at which F becomes nil approaches the value of 90 deg./C or 270 deg./C as the number of cylinders increases. In a single-cylinder engine, $F = 1.25K$ when $\theta = 0$ deg. and $-0.75K$ when $\theta = 180$ deg., where $K = 0.0000284N^2WR$.

In a four-cylinder engine, $C = 2$, the simple harmonic is eliminated, and F attains maximum values when $\theta = 0$, 90, 180, and 270 deg. The unbalanced force is K at the dead centers and $-1.033K$ at the 90-deg. points.

In a six-cylinder engine, $C = 3$ and the maximum unbalanced forces are $\pm 0.0004464K$ at 0 and 30 deg. respectively.

In a straight eight, $C = 4$ and $F = \pm 0.0328K$ when $\theta = 0$ and 45 deg.

The crank positions for the maximum and the minimum torques are best determined by the principles of differential calculus. The equation for the total torque is written as the sum of the T and M torques of equations (3) and (4), involving only the functions in multiples of $C\theta$. The first derivative of this expression with respect to θ, being equated to zero, is solved for θ. At least two real roots will be found, one of which corresponds to the angle of maximum torque, the other to the angle of minimum, or of maximum negative, torque.

To illustrate the process, let it be required to determine the angles of maximum and minimum fluid torque in a six-cylinder engine. Differentiating equation (4) for the third and the sixth harmonics, equating the result to zero and simplifying, the positions of the maxima are defined by the equation

$$\sin 3\theta + 0.933 \sin 6\theta + 2 \cos 3\theta = 0.$$

The solution is expedited by substituting $2 \sin 3\theta \cos 3\theta$ for $\sin 6\theta$ and dividing through by $\cos 3\theta$, whence we have

$$\tan 3\theta + 1.866 \sin 3\theta + 2 = 0.$$

The two real practical roots are readily evaluated by inspection and trial. Obviously, $\tan 3\theta$ cannot be positive, since $\sin 3\theta$ must not exceed unity. The angle 3θ is therefore limited to the second and fourth quadrants in which $\sin 3\theta$ is respectively positive and negative. The equation is satisfied by the values $\theta = 34$ deg. 55 min. and 107 deg. The tangential force corresponding to the first angle is 231 lb. and to the second, 18 lb., per unit head-area of one piston. Knowing the cylinder bore and the stroke, the total torque is simple, the product of the area by the crank radius and the unit tangential force.

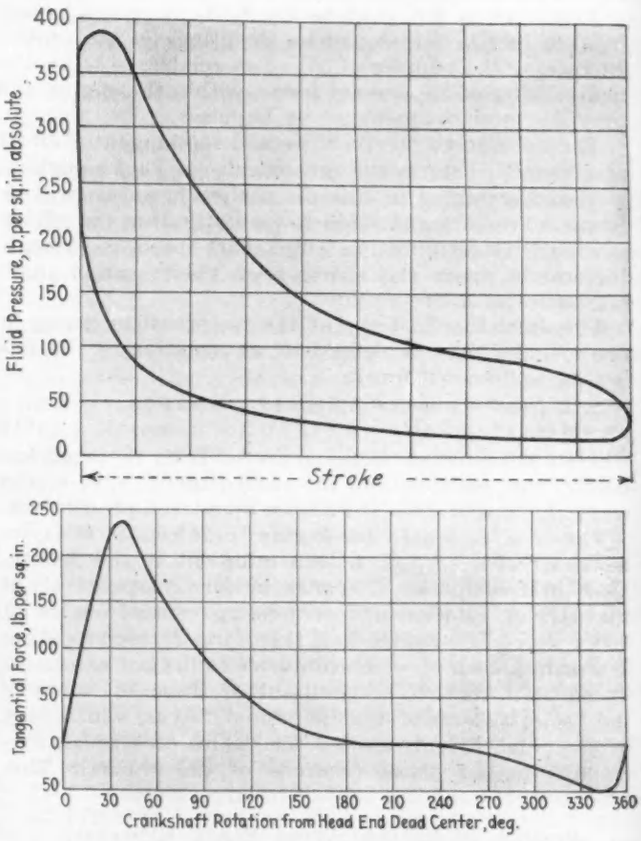


FIG. 1—FLUID-PRESSURE TORQUE

Assuming that the Pressure-Volume Characteristics of the Engine Cycle Are Similar to Those Shown in the Indicator Diagram in the Upper Half of This Figure, the Tangential Force at the Crank Is Given in the Lower Half. This Curve, Which Covers One Complete Revolution, Is a Composite Tangential-Effort Diagram for Each Pair of Cylinders Whose Cranks Are in Line

As the cylinder number increases, both the inertia torque and the fluid-pressure torque approach uniformity at all speeds. In an engine of few cylinders, although the torques due to inertia and fluid pressure fluctuate widely, it is possible to balance one against the other and thereby to produce a quite satisfactory resultant effect. To illustrate the relative inertia balance and uniformity of torque, line engines of 2, 4, 6, 8, and 10 cylinders will be analyzed under the following conditions: The fluid pressure-volume characteristics are taken from the upper half of Fig. 1, and are assumed to be independent of the engine speed. The cylinder bore, B, is 3.5625 in., whence the piston area is 10 sq. in. The stroke, $2R$, is 5 in. The weight of the reciprocating parts is 2.25 lb. per cylinder. Speeds of 1000, 2000, and 4000 r.p.m. are investigated.

Balance of Inertia and Fluid-Pressure Torques

The simplicity of the computation increases with the cylinder number. Since the four-cylinder analysis involves certain aspects that are absent from the other engines, it will be studied in some detail. The equations for the inertia force, F, and the inertia torque, T, both involve the term $0.0000284N^2WR$ which, at 4000 r.p.m., becomes in this problem $K = 2555$. Then, as previously explained, the maximum free force in a vertical engine is K, or 2555 lb. upward when $\theta = 0$ deg. and 180 deg., and $-1.033K$ or 2640 lb. downward at 90 and 270 deg.

The total torque, being the sum of T and M in equations (3) and (4), is defined by the following equation, using the value 5110 for $2K$, 10 for the piston-head area, 2 for C, and 2.5 for R:

$$Q = 5\,[5110\,(-0.5\sin 2\theta - 0.0161\sin 4\theta) + 10\,(38 - 13\cos 2\theta - 18\cos 4\theta - 7\cos 6\theta + 54\sin 2\theta + 17\sin 4\theta)]\ \text{lb-in.} \qquad (5)$$

Collecting like terms, differentiating with respect to θ, and reducing to functions of 2θ, we have

$$\frac{dQ}{d\theta} = 7200\,(\sin 2\theta\cos 2\theta + 1.17\sin 2\theta\cos^2 2\theta - 0.111\sin 2\theta - 2.8\cos 2\theta + 0.49\cos^2 2\theta - 0.245). \qquad (6)$$

The angles for which $\frac{dQ}{d\theta}$ becomes nil are the positions of maximum and minimum torque.

This expression, being transcendental, does not admit of a direct complete solution but, inasmuch as only the real roots between 1 and -1 are of interest, the method of inspection and trial is satisfactory. The equation is manifestly dominated by the term $-2.8\cos 2\theta$ for all values of 2θ except in the regions adjacent to 90 and 270 deg., where the term $-0.111\sin 2\theta$ assumes precedence. The dominating term must be positive in order to offset the constant -0.245. This condition bars 2θ from the first quadrant and requires that $-2.8\cos 2\theta$ control the solution in the second quadrant and be negligible in the fourth quadrant. The fact that the absolute magnitude of $\sin 2\theta$ never exceeds unity elimates 2θ from the fourth quadrant by reason of the small coefficient of $\sin 2\theta$. Acting upon this reasoning, and bearing in mind the effect of the principal terms, the solutions $\theta = 49$ deg. 56 min. and 134 deg. are derived by trial. The total effective torques corresponding to these two angles are computed, with the help of equation (5) to be $\varphi = -7400$ lb-in. when $\theta = 49$ deg. 56 min., and $\varphi = 12{,}890$ lb-in. when $\theta = 134$ deg.

These results are somewhat startling, for the maximum fluid torque occurs in the neighborhood of 37 deg., as shown in the lower half of Fig. 1. The torque required to accelerate all four pistons together at this high speed, however, entirely masks the fluid torque and even requires that energy be drawn from the flywheel to maintain the speed. This energy is, of course, returned to the flywheel as the pistons approach the end of the stroke, and, as a matter of computation, 98 per cent of the effective torque at 134 deg. is supplied by the reciprocating parts. The enormous effect of the inertia component of the torque is evident from equation (5), in which the term $-2555\sin 2\theta$ is by far the largest item involved.

If the engine speed is reduced to 2000 r.p.m., all inertia effects drop to one-fourth their former values, the maximum torque of 3460 lb-in. occurs at 126 deg. and the minimum of 1020 lb-in. at 69 deg., exclusive of the zero torque at the dead centers. Lowering the speed has improved the uniformity of the torque considerably and a little further reduction would be beneficial. The only positions in the cycle at which the torque is independent of the speed are the dead centers and the 90-deg. points.

Application of Analyses

The results of a series of similar analyses for two, four, six, eight, and ten-cylinder line-engines are summarized in Table 1. The effects of cylinder number and of engine speed upon the inertia forces and the resultant torques are very apparent. The twin-cylinder engine is of the side-by-side type with cranks in line, which leads to good firing balance but poor inertia balance. The data for this engine in Table 1 cover a complete revolution at 4000 r.p.m., but only the power stroke at 1000 r.p.m.

The four-cylinder engine can be designed to give a pleasing torque-characteristic over a rather narrow speed-range by proper attention to the reciprocating weights. The axial reciprocating-forces cannot be neutralized among themselves, although auxiliary balancing-devices can be installed to improve the smoothness of operation.

The six-cylinder engine has very small unbalanced inertia-forces even at high speeds, but the torque is subject to considerable fluctuation.

In the straight eight, the torque is not affected appreciably by the speed, nor are the inertia forces excessive, the extent of the latter unbalance being equivalent to the force exerted by slightly less than an ounce of metal applied to one piston-pin.

The ten-cylinder engine possesses very uniform torque and practically perfect reciprocating balance.

Bibliography

The following references will be found useful in developing and extending the foregoing analysis:

A Treatise on Engine Balance Using Exponentials, by P. Cormac

The Gasoline Automobile, by P. M. Heldt

Mechanics of the Gasoline Engine, by H. A. Huebotter

Gas Engine Design, by C. E. Lucke

—H. A. Huebotter.

TABLE 1—RECIPROCATING FORCE AND TORQUE IN MULTICYLINDER LINE-ENGINES

Number of Cylinders	Speed, R.P.M.	Angle θ Deg.	Force F Lb.	Angle θ Deg.	Force F Lb.	Angle θ Deg.	Torque Q[a] Lb-In.	Angle θ Deg.	Torque Q Lb-In.
2	4,000	0	6,400	90	— 1,320	30.0	— 2,310	114.0	7,610
2	4,000	180	— 3,840	270	— 1,320	321.0	7,200	242.5	— 6,100
2	1,000	0	400	90	— 83	39.0	5,325	169.0	183
4	4,000	0	2,555	90	— 2,640	49.93	— 7,400	134.0	12,890
4	2,000	0	640	90	— 660	69.0	1,020	126.0	3,460
4	1,000	0	160	90	— 165	37.0	5,010	167.0	— 800
4	2,075	0	690	90	— 710	30.0	2,375	150.0	2,375
4	1,840	0	540	90	— 560	45.0	2,800	135.0	2,800
4	1,550	0	380	90	— 400	60.0	2,325	120.0	2,325
6	4,000	0	1.14	30	— 1.14	23.38	— 1,930	87.93	8,565
6	2,000	0	0.28	30	— 0.28	38.67	4,035	73.0	3,355
6	1,000	0	0.07	30	— 0.07	35.5	5,325	109.5	715
8	4,000	0	— 84	45	84	38.5	5,800	83.5	1,800
8	2,000	0	— 21	45	21	35.1	6,140	80.1	1,460
8	1,000	0	— 5.25	45	5.25	34.38	6,240	79.38	1,360
10	4,000	0	0.0006	18	0.0006	32.08	6,750	68.08	2,780
10	2,000	0	....	18	.....	32.78	6,710	68.78	2,820
10	1,000	0	....	18	.....	32.95	6,700	68.95	2,830

[a] The torque, Q, represents either a maximum or a minimum value except in the four-cylinder engine at 2075, 1840, and 1550 r.p.m.

Analytical versus Graphical Method

The foregoing article by H. A. Huebotter is of interest not only because of the subject, engine vibration, but also because of the method used in dealing with it, the analytical. It is, from this point of view, a companion piece to a paper entitled Reciprocating Balance in Engines of Six and Eight Cylinders, by M. V. Davidson[3], published in a previous issue of THE JOURNAL[3].

Professor Davidson, in his paper, modified the analytical method with a free use of graphical illustrations. In his opinion, the analytical method as used by Mr. Huebotter and by P. Cormac[4] is somewhat abstruse and complex for dealing with the problems under consideration. He points out, as a disadvantage of this method, that it gives no complete and definite expression for the unbalance force due to inertia, but shows that beyond a certain point for each case the harmonics are not zero. He thinks also that the effort to treat the question of torque by purely analytical methods will not yield as satisfactory results as the combination of the analytical method with a free use of graphical illustrations.

In connection with the paper published in the present issue, Professor Davidson refers to Mr. Huebotter's proposal to examine only maximum and minimum resultants. He feels that the calculation of enough values for the plotting of a curve would be better and more useful for studying and comparing effects.

Further work on engine balance is shown in Fig. 2. The figure includes a developed indicator-diagram, an effective-piston-pressure diagram, analyzed turning-effort diagrams and a curve combining the latter. This incorporates a problem dealt with at the University of South Dakota, which covers practically the same ground as Mr. Huebotter's present paper. In transmitting it, Professor Davidson makes the following comments:

> We have calculated the tangential turning-force rather than the torque. The product of our forces by the crank radius will give torque at the various points for which the forces are taken. * * *
>
> We have combined the inertia and fluid forces instead of separating them, and this has been done for each of the four strokes, for each cylinder of a six-cylinder engine. The resulting tangential-effort curves have been plotted in their correct phase-relations, and then the six combined in the curve at the bottom of the print.
>
> The results we obtained proved very instructive, and the combination curve illustrates very nicely the torque condition of the six-cylinder engine and its effect on oscillatory balance. I have sketched in an additional curve on this diagram. This curve, combined with the six-cylinder curve, would give that of a 12-cylinder line-engine with pairs of cranks at 60 deg. Such an engine would have fine torque-balance, almost perfect axial-balance, and perfect connecting-rod oscillatory-balance. In the six-cylinder engine the total inertia-effect is so almost absolutely balanced that this effect on torque is also almost eliminated.

Taking the opposite point of view to Professor Davidson on the question of methods, Mr. Huebotter finds the analytical methods as used by himself and Cormac the simpler of the two choices, and says of the latter's book: "His work is so complete, and mathematically so elegant, that it overshadows every other analysis I have ever seen."

Dr. Benjamin Liebowitz, another commentator on the subject of methods, says:

> There is no need for selling the analytical method in competition with the geometrical or graphical; each method has its advantages, and the final selection by any engineer as to method would be one of temperament, taste and training, and not one of absolute superiority of any one method over another.

[3] Department of Mechanical Engineering, University of South Dakota, Vermillion, S. D.

[3] See THE JOURNAL, September, 1927, p. 315.

[4] See A Treatise on Engine Balance Using Exponentials; by P. Cornac.

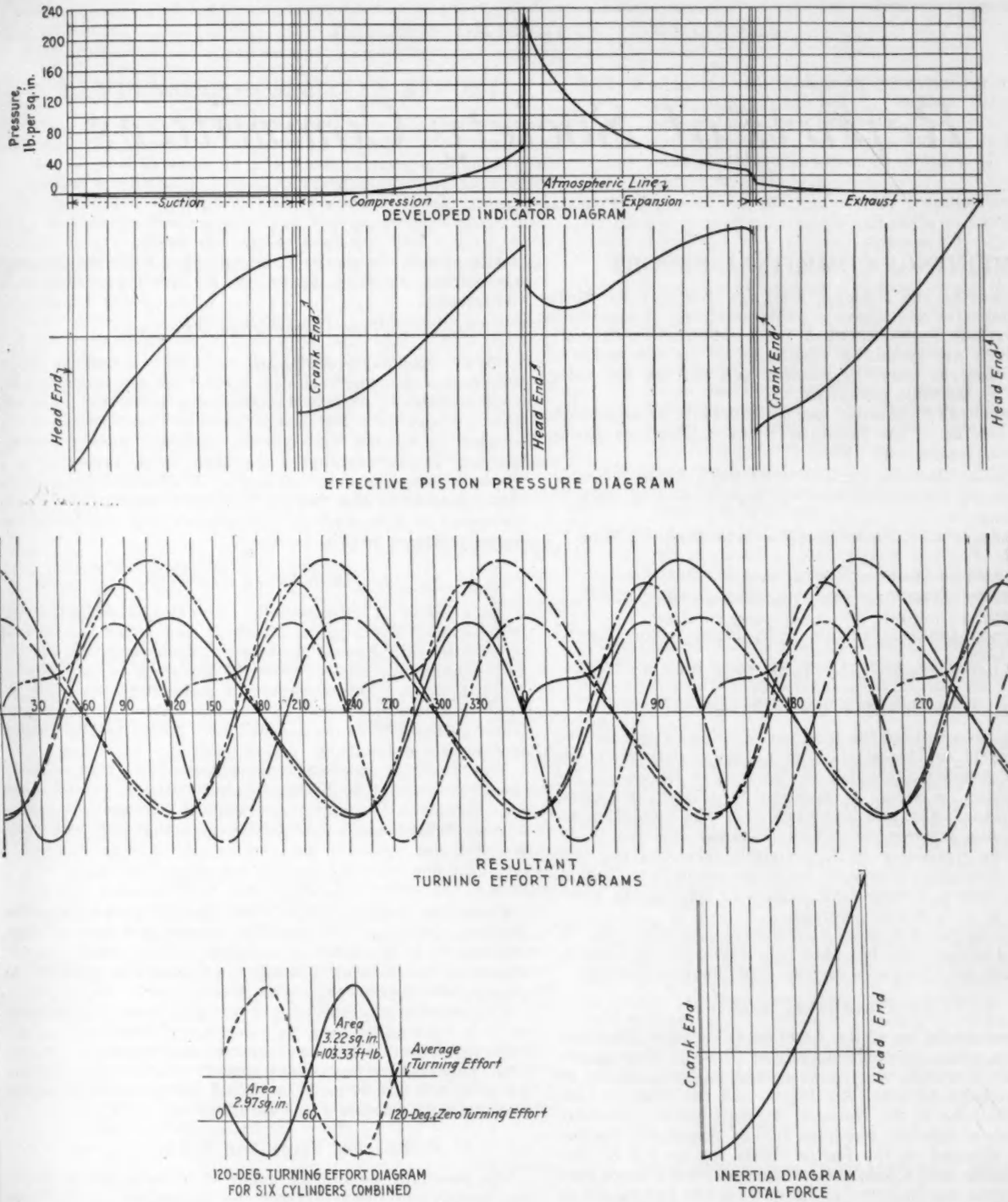


FIG. 2—TURNING EFFORT IN A SIX-CYLINDER ENGINE

The Tangential Effort Curves for Each of the Four Strokes and for Each Cylinder Have Been Plotted in Their Correct Phase Relations, and the Six Combined in the Solid Curve at the Lower Left Corner. The Dotted Curve on This Diagram, Combined with the Six-Cylinder Curve, Would Give that of a 12-Cylinder Line-Engine with Pairs of Cranks at 60 Deg.

The Following Should be Considered in Conjunction with the Curves:

Engine Data:

Make, Hupmobile Six, 1925; Bore, 3⅛ In.; Stroke, 4¼ In.; Rod Length, 8¾ In.; Center of Gravity of Rod, 2⅛ In. from Crank-Pin; Weight of Rod, 1.80 Lb.; Weight of Piston Wrist-Pin, 1.505683 Lb.; Speed, 3000 R.P.M.; Reciprocating Weight, (2.125/8.75) x 1.8+1.506=1.943 Lb.

Inertia Force Equation: $F=\frac{WV^2}{g}\left[\frac{R\cos\phi}{(K+C^2\cos^2\phi)^{3/2}}-\frac{1-\cos^2\phi}{(K+C^2\cos^2\phi)^{1/2}}+\frac{\cos\phi}{C}\right]$

F=Force Required To Accelerate Reciprocating Parts; $K=R^2-C^2$; ϕ=Crank Angle; C=Crank Length in Feet; R=Connecting-Rod Length in Feet; W=Weight of Reciprocating Parts; V=Crank-Pin Velocity in Ft. per Sec.; g=Acceleration of Gravity in Ft. per Sec.

Turning-Effort Equation: $T=\frac{P\cos[90°-(\phi+\alpha)]}{\cos\alpha}$

T=Turning Effort; P=Force on Piston; ϕ=Crank Angle; α=Rod Angle

Speed Variation: 50 R. P. S., Mean

Kinetic Energy for Disc $=\frac{\pi^2 r^4 \gamma N^2}{g}$

(Flywheel Assumed To Be 15 x 2 In. Cast-Iron Disc.)

Kinetic Energy $=CN^2$ $C=\frac{\pi^2.(625)^4.(2.450)}{12(32.16)}=11.15$)

Kinetic Energy $=C(N^2_1-N^2_2)$ $103.33=11.15$ $(50^2-N^2_2)$

$N^2_2=2500-9.27$

$N_2=49.8$ R. P. S.—Minimum $N_2=50.2$ R. P. S.—Maximum

Reports of Society Committees

MEETINGS COMMITTEE REPORT

In arranging the National Meetings this year the Meetings Committee has appointed subcommittees of specialists in the various branches, called Technical Program Committees, which are assuming responsibility for the technical papers. General meetings matters and policies are being handled by the main committee.

The Meetings Committee has made definite arrangements for the holding of the following National Meetings during the administrative year 1928:

Summer Meeting, June 26 to 29, 1928, Quebec
Western Aeronautic Meeting, Sept. 13 and 14, 1928, Los Angeles
Transportation Meeting, Oct. 17 to 19, 1928, Newark, N. J.
Production Meeting, Nov. 22 and 23, 1928, Detroit
Eastern Aeronautic Meeting, Dec. 6 and 7, 1928, Chicago
Annual Dinner, Jan. 10, 1929, Hotel Astor, New York City
Annual Meeting, Jan. 15 to 18, 1929, Detroit

The Summer Meeting

The decision to hold the Summer Meeting at Quebec was based largely on the letter-ballot of the Society members, the vote showing a decided preference for Quebec. The places voted on were, in addition to Quebec, an ocean cruise, Spring Lake, and Atlantic City. The committee expects to take a straw vote at the Summer Meeting to determine the preference of the members regarding the 1929 Summer Meeting. Places to be voted on include Quebec, an ocean cruise, French Lick, Atlantic City, Spring Lake, and Denver or Colorado Springs.

The Technical Program Committee, of which W. R. Strickland is chairman, has been responsible for the comprehensive technical program for the 1928 Summer Meeting.

The Aeronautic Meeting

On recommendation of the Aeronautic Technical Program Committee, under the chairmanship of Glenn L. Martin, two Aeronautic Meetings will be held: one in Los Angeles at the time of the National Air Races, and the other in Chicago at the time of the National Aircraft Show. Decision to hold one of the two meetings in Los Angeles is the result of a demand on the Pacific Coast for an S.A.E. National Meeting and recognition of the fact that a large part of the aeronautic industry is located on the Coast. It is expected that a large number of the Eastern aeronautical engineers will attend the National Air Races.

Holding the Eastern Aeronautic Meeting in Chicago will mean that virtually every aircraft manufacturer east of the Rocky Mountains will be within 1 day's flight of the meeting. A comprehensive technical program has been arranged by the Technical Program Committee, which consists of Glenn L. Martin, Chairman; E. Favary, E. P. Warner, Earl D. Osborn and L. M. Woolson.

The Transportation Meeting

Under the chairmanship of F. C. Horner, the Transportation Technical Program Committee is arranging for the papers to be presented at the Transportation Meeting, which will be held in Newark, N. J., Oct. 17 to 19. The Meetings Committee has not reached a final decision as to the place for this meeting, but definite action is expected within the next few weeks.

Other members of the Transportation Technical Program Committee are F. K. Glynn, A. W. Herrington and J. F. Winchester.

The Production Meeting

E. P. Blanchard, chairman, and other members of the Production Meeting Technical Committee are preparing for four technical production engineering sessions in Detroit, Nov. 22 and 23. The Detroit Section has offered to cooperate in holding this meeting and will have a Section meeting on the evening of the 22nd, to be preceded by a dinner and special entertainment. If sufficient demand for the organization of a Detroit Section Production Division is evidenced at this meeting, the Section will undertake the organization of such a division.

The Annual Meeting

As a result of a letter-ballot of members attending the 1928 Annual Meeting, the Meetings Committee has decided to hold the 1929 Annual Meeting the week preceding the Detroit Automobile Show, instead of the week of the show as in past years. This change will make it possible for attending members who do not live in Detroit to obtain reduced railroad-fares, and it will also mean less congestion in the Detroit hotels.

The technical program for the Annual Meeting is under the direction of G. L. McCain, chairman of the Annual Meeting Technical Program Committee. Arrangements have already been made for several papers that are to be presented.

Technical Papers

Committees responsible for the technical programs of the National Meetings will greatly appreciate receiving suggestions from members as to subjects that should be discussed at the several meetings and men well qualified to prepare and present papers on them.

The practice of preprinting the papers is to be continued, as it is believed by both the Meetings Committee and the Publication Committee that more valuable discussion results when papers have been studied prior to their presentation. An effort will also be made to publish abstracts of the papers that are to be published in The Journal.

Broader Scope for Meetings

The Meetings Committee hopes to broaden the scope of the Society activities through the discussion of civic and National problems of automotive engineering. It is felt that, through the discussion of such subjects, the Society will become of greater value, not only to the membership, but to the Country at large.

An endeavor is being made by the Committee to promote discussion of the business phases of engineering. Norman Shidle's paper, scheduled for presentation at the first session of the Summer Meeting, is in line with these views of the Committee. Other papers touching upon the broader aspects of the automotive engineer's profession and daily activity are to follow.

In organizing and arranging the various National Meetings, the Committee is encouraging a greater participation by the Sections. Active interest of the Sections in National Meetings is regarded as essential to the success of the latter.

John A. C. Warner,
Chairman

MEMBERSHIP COMMITTEE REPORT

The Membership Committee has been unusually active during the last year, cooperating directly with the Sections in several cases to aid them in their campaigns to increase membership. These Section campaigns have been in the nature of steps to gain National Society members as well as Section members; so the result as a whole has been to strengthen the entire Society. The Detroit Section in particular has put on an intensely active campaign which has resulted, so far, in an addition of 123 applications for membership.

As of May 31, 1928, the Society's membership, including Affiliate Member Representatives, was 6430. This showed an increase of 410 over the figure for the same date last year.

The number of members delinquent in Society dues is comparative with the figure of the previous year at the same time, being approximately 6 per cent of the total membership. A direct follow-up is maintained to keep this figure at the minimum.

Comparative membership figures are given in the following table:

	May 31, 1927	May 31, 1928
Members, including Foreign and Service	3,223	3,455
Associates	1,956	2,094
Juniors	537	572
Affiliates	111	114
Affiliate Member Representatives	193	195
Total	6,020	6,430
Enrolled Students	339	472

Applications received during the last 12 months totaled 990, against 873 for the previous year.

The percentage of applicants qualifying was 70.3 against 87.5 per cent for the same period in 1927. The Committee is making a study of the probable reasons for this. One thought is that the major reason is the relatively large percentage of applicants elected as Associate who do not qualify because they are dissatisfied with the Associate Grade, or do not understand that that grade is not inferior to, but merely different from, Member Grade of Membership. The Committee is endeavoring to remedy this situation by giving a suitable explanation of the importance and seriousness of the Committee and Council work in the proper grading of applicants for membership according to a sufficiently high scale.

The Membership Committee wishes to express its sincere appreciation to the members who assisted in aiding this growth of the Society. The Section officers and Section Membership Committees are also to be complimented on their active interest in the work.

F. K. GLYNN,
Chairman

OPERATION AND MAINTENANCE COMMITTEE REPORT

Following the work done last year by the Operation and Maintenance Committee, the present Committee decided to concentrate on a few major topics. Accordingly, the personnel of the Committee this year was selected largely on the basis of concentrating the work in a few individuals without making it burdensome on any one of them. Two committee vice-chairmen were appointed: E. C. Wood, representing the West Coast interests, and F. C. Horner, representing the East Coast groups. Chairman R. E. Plimpton represents the Northern Central groups.

The subjects selected for study this year, each assigned to a subcommittee, are:

(1) Forms for vehicle data-sheets suitable for listing information furnished by vehicle builders on subjects such as clearances, tolerances, fits, interchangeability and replacement parts, and maximum load-allowance on vehicles. J. F. Winchester is chairman

(2) Study of the effect on vehicle maintenance of the use of such accessories and parts as air-cleaners, oil-filters and shock-absorbers; E. C. Wood, chairman

(3) Selecting and training of mechanics and their payment; and time-study; chairman, T. L. Preble

(4) Man-power, that is mechanics, washers and the like, required per vehicle operated; and the seasonal fluctuation in man-power requirements. F. C. Horner is chairman. Donald Blanchard, who is a member of the Operation and Maintenance Committee, outlined this project during Mr. Horner's recent illness

(5) Training and selecting of drivers, and their payment; and operating safety-measures. Ethelbert Favary is chairman

(6) Budgeting methods and practices, and the purposes for which operating expense and costs are compiled; assigned to W. F. Banks, chairman

(7) Administrative systems and methods and paper work in general. L. V. Newton is chairman.

The present plan is that the several subcommittees shall complete their work by late summer so that their reports will constitute an important part of the program of the Society's National Transportation Meeting to be held next fall.

Probably the most important undertaking so far this year has been to determine the feasibility of a broad National survey of the economics of motor-vehicle transportation. This was proposed originally at the Transportation Meeting in Chicago last fall. A plan for such a survey was subsequently outlined by Chairman Plimpton and has been discussed with representatives of the National Automobile Chamber of Commerce and of some of the educational institutions equipped for such work. Although a broad study of this kind is believed to be desirable as a means of making fundamental information available to both motor-vehicle fleet operators and vehicle manufacturers, its initiation has been delayed pending decision as to the feasibility of the project at this time, how and by whom it should be supported and financed, and by whom the survey should be conducted.

These matters are now receiving careful consideration and it is hoped to make definite progress before the Transportation Meeting next fall.

R. E. PLIMPTON,
Chairman

PRODUCTION COMMITTEE REPORT

This year's work of the Production Committee, which is the successor to the Production Advisory Committee of last year, has been handicapped by much the same difficulty that existed generally last year in enlisting the active participation in committee work by the production engineers.

To bring the plans of the Committee to the direct attention of production engineers and executives, a special letter was sent to a selected list of more than 125 of the "keymen" in the industry early in January, explaining the Society's desire to carry on active work in their interest, and inviting them to a conference in Detroit during the Annual Meeting there. At this conference a free and open discussion, both critical and favorable, was the foundation for the reorganization of the Production Committee this year.

Many topics were suggested that were grouped and classified, and subcommittees or groups were appointed, each to study a given classification of subjects, as follows:

(1) Material Handling and Control
(2) Processes and Equipment
(3) Time Study and Personnel Relations
(4) Production Expense (Costs and Budgets)
(5) Production Standards
(6) Inspection Methods
(7) Section Activities on Production

The group on Production Standards is composed of the Production Division of the Society's Standards Committee and has been the most active so far, as a number of Machine-Tool and Small-Tool Standards are now in progress. These are referred to in the general report of the Standards Committee, which includes Sectional Committee activities.

The other groups have been organized and their work planned in cooperation with the chairman of the general Production Committee.

The scope of the work undertaken by the Production Committee is comprehensive and is subject to conditions that do not exist in other branches of the Society's activities. To develop the work as effectively as possible, a Production Advisory Board supplements the Committee to assist in establishing broad policies and the best procedure. The Advisory Board consists of F. T. Ellis, Cadillac Motor Car Co.; A. R. Glancy, Oakland Motor Car Co.; F. E. Moskovics, Stutz Motor Car Co.; and DuBois Young, Hupp Motor Car Corporation. This Board is not a formally organized committee but will lend its cooperation by personal interview or correspondence with the chairman and members of the Committee.

Direct participation by members of the Production Committee in the work of the other general committees of the Society was discontinued this year, as it was believed that the new plan would be more productive of results until a greater interest in production activities develops generally among the entire membership of the Society.

E. P. BLANCHARD,
Chairman

PUBLICATION COMMITTEE REPORT

Since the Annual Meeting in January, the Publication Committee has been making a special study of the TRANSACTIONS of the Society with a view to developing a means of speeding up their publication and, at the same time, publishing the papers in the most desirable and economical way. The plan which seems to meet all conditions best is to change the TRANSACTIONS to S.A.E. JOURNAL size so that the page make-up used in THE JOURNAL can be used in TRANSACTIONS. To make it possible for the TRANSACTIONS, if so published, to be placed upright in the average bookcase, it will be necessary to shorten by 1 in. the length of the type page in the S.A.E. JOURNAL, keeping the over-all dimensions of the monthly the same as at present, however.

The Publication Committee is in favor of the compilation of a Cumulative Index, as proposed by many members, the form of the Index to depend on the form decided upon for TRANSACTIONS.

An endeavor has been made by the Committee to improve the appearance and the readability of the S.A.E. JOURNAL by a more pleasing arrangement of the text pages and also by arranging the material in a logical and suitable sequence. The object has been to make the S.A.E. JOURNAL more attractive and interesting than the usual engineering-society journal without adopting the "make-up" of the popular magazine. The members of the Publication Committee feel that the changes made have been appreciated, one bit of evidence being the comments made at the May 7 meeting of the Detroit Section by B. J. Lemon, who said in part that "during the past year the Society has administered large doses of humanizing to the S.A.E. JOURNAL."

The Publication Committee expects that it can make a final report at the 1929 Annual Meeting covering the complete publication policy of the Society.

JOHN YOUNGER,
Chairman

RESEARCH COMMITTEE REPORT

The Research Committee and its subcommittees have continued to devote the major portion of their attention to furthering the progress of the four main research projects of the Society, concerned with fuels, headlighting, highways and riding-qualities.

FUELS

As in the past, the Fuels Subcommittee has acted in conjunction with representatives of the National Automobile Chamber of Commerce and the American Petroleum Institute in supervising the Cooperative Fuel Research being carried on at the Bureau of Standards.

Substantial progress has been made in the last 6 months on the program laid out for the study of gasoline volatility. Previously, a correlation had been established between the A.S.T.M. distillation curve and the equilibrium-air distillation curves, the latter affording data more pertinent to automotive engineers, between the 5 and 95-per cent points. A continuation of this work by an investigation of that portion of the curve above the 95-per cent point is reported to the Society in a paper presented at the Research Session at the Summer Meeting.

Marked progress also has been made on another topic of the Cooperative Fuel Research, that is, the influence of fuel characteristics on engine acceleration. A paper covering this portion of the work, prepared for presentation at the Research Session, deals with the improved apparatus and test procedure recently developed and the effect upon acceleration of air-fuel ratio, manifold temperature and fuel volatility, particularly the 50-per cent point.

Other subjects of investigation have been the theoretical aspects of detonation, especially the relation of ignition temperatures of fuels to their detonation characteristics and the mechanism of the oxidation of hydrocarbons and hydrocarbon fuels; the detonation characteristics of fuels now available to motor-car drivers and the possibility of developing a rugged, inexpensive engine that will be generally acceptable as standard equipment for the measurement of detonation.

HEADLIGHTING

The study being made at the Bureau of Standards, with funds provided by the National Automobile Chamber of Commerce, has been continued under the technical direction of the Research Committee. This investigation by road tests, supplemented by laboratory experiment, is directed toward determining the optimum light distribution under various road conditions, at the same time protecting approaching drivers from glare. The first part of the research, as reported in the Automotive Research section of the March issue of THE JOURNAL, was concerned with the effect of various factors on visibility distances with no opposing lights. During the last 6 months the tests have considered, in addition, the effect of opposing lights. Visibility distances have been determined and photometric measurements made of the light coming into the driver's eyes from opposing lights.

HIGHWAYS

As part of the Cooperative Committee on Motor-Truck Impact Tests, the other members of which are representatives of the Bureau of Public Roads and the Rubber Association of America, the Highways Subcommittee has continued its interest in the motor-truck impact-test work being conducted at the Bureau of Public Roads. A new development during the last 6 months is the enlisting in this project of the cooperation of the Bureau of Standards, which

is lending its assistance in instrumentation for further testing. Two of the instruments now being developed are a device for calibrating accelerometers and a ten-element contact-type accelerometer.

Riding-Qualities

The development at Yale University of a vibrating chair to determine the susceptibility of persons to vibrations of various amplitudes and frequencies, in which the Riding-Qualities Subcommittee is interested, is nearing completion. Efforts are also being made to obtain funds to carry out a similar project, to be coordinated with that at Yale University, at the Bureau of Standards with equipment and instruments there available.

Wheel-Alignment Research

In view of the importance of and interest in the subject of wheel alignment, the Research Committee at its January meeting authorized the appointment of a subcommittee to get in touch with tire and motor-car manufacturers to obtain from them such information as is available on the fundamentals affecting wheel alignment and to correlate and digest the data furnished so that it can be presented in a paper before the Society. This subcommittee has been organized and has received from manufacturers assurances of assistance that promises to make its work of great value.

Mechanical Springs

The Society is cooperating with the Special Research Committee on Mechanical Springs of the American Society of Mechanical Engineers and is represented on this Committee by B. Liebowitz (general), T. Franzen (leaf springs), and E. W. Stewart (coil springs).

A bibliography of about 600 references has been published by the Committee covering the general field of metallic springs. Research work has been started by Mr. Hoadley, under direction of Professor Sayers, at Union College, to determine fundamental constants for the Code of Design, the present work being confined to steel in flexure. A paper on this work will be read at the annual meeting of the A.S.M.E.

The Committee has been very fortunate in securing the facilities of the Naval Experimental Station at Annapolis, and the services of Dr. McAdam, who is noted for his work on fatigue. The Committee will be glad to receive suggestions and problems suited to these facilities.

Research Department

During the last 6 months the Research Department has added to its library equipment in accordance with the recommendations of the Library Committee at its meeting on Jan. 11, approved by the Council at the Jan. 24 meeting. The equipment includes new shelving capacity and the binding of additional magazines. The technical information files have been added to, and the information service maintained, 505 requests for information having been taken care of by letter in the first 5 months of 1928 as well as personal and telephone inquiries. Contributions to THE JOURNAL have included 10 columns of Notes and Reviews each month and copy for Automotive Research. The Research Department has also assisted in carrying out the research projects of the Society.

H. C. DICKINSON,
Chairman

SECTIONS COMMITTEE REPORT

Perhaps the most important Section event during the year 1927-1928 has been the success of the Detroit Section in the Detroit-Metropolitan Section membership campaign competition, which resulted in making the Detroit Section the largest of the thirteen Sections of the Society.

The increase in Section membership during the year is given in Table 1. This table also shows the number of Society members residing in the territory of each Section and the percentage who are members of the Section. These figures indicate to a large extent the effectiveness of the appeal which the meetings of the several Sections have for the Society members in their several territories.

TABLE 1—SECTION MEMBERSHIP INCREASE AND PERCENTAGES OF SECTION MEMBERSHIP TO SOCIETY MEMBERS IN SECTON TERRITORIES

Section	Number of Section Members 1927	Number of Section Members 1928	Number of Society Members in Territory, 1928	Percentage of Section Members to Society Members, 1928
Buffalo	114	116	115	101
Chicago	303	292	481	61
Cleveland	277	300	433	69
Dayton	64	76	155	49
Detroit	807	931	1,110	84
Indiana	114	124	160	78
Metropolitan	833	897	1,031	87
Milwaukee	98	111	156	71
New England	129	146	245	60
Pennsylvania	224	234	238	98
Washington	65	69	86	80
Northern California	88	91	150	61
Southern California	93	100	119	84
Total	3,209	3,487	4,479	78[a]

[a] Average.

The Sections Committee is studying several questions relating to the activities of the Sections. Most important is the collection of Section dues, the proposal having been made that these dues should be compulsory. Although this proposal is not yet favored by all members of the Committee, it is possible that a satisfactory way can be found in which to accomplish the correct result.

The Committee is also studying the relationship between the Sections and the Society Headquarters, a complete statement having been compiled for consideration at the semi-annual meeting of the Sections Committee at the Summer Meeting.

VINCENT G. APPLE,
Chairman

STANDARDS COMMITTEE REPORT

Substantial progress was made during the first half of the year by the divisions of the Standards Committee, working largely through subdivisions, by concentrating on the more important of approximately 100 subjects scheduled. There is still difficulty in securing adequate attendance at division meetings. This undoubtedly is due largely to the exacting requirements of their own work on the division members' time. In many cases, however, the members who could not attend meetings have sent representatives. Special efforts should be made, if necessary, to attend the meetings so as to make it possible for the divisions to accomplish the maximum results; bearing in mind that the work is beneficial to the members individually and to their companies as well as to the Society members in general. Although these benefits may be obscure and frequently are not evident except over relatively long periods, they are nevertheless real and will not be forthcoming if the work is hampered by the lack of attention and attendance at meetings or by insufficient review by the industrial interests. To facilitate the work as much as possible, most of it is now handled through subdivisions of specialists on each subject. The work in progress has been assigned to about 65 subdivisions to expedite it and make it more effective.

The Standards Committee this year comprises 22 divisions. The Agricultural Power Equipment, the Electric

Vehicle, the Isolated Electric-Lighting-Plant, and the Motorcycle Divisions are the only ones for which subjects have not been scheduled. This failure to assign subjects has been largely because only limited active interest in standardization has been shown by these groups, which should properly initiate their own standardization projects rather than have them started from other sources.

The work of the Ball and Roller-Bearings, the Production, and the Screw-Threads Divisions is tied in considerably with work of sectional committees organized under the procedure of the American Engineering Standards Committee. This is true particularly of the Production Division, as interest in the standardization of machine-tools and their related elements has become very active this year.

Outstanding Projects

A prominent feature of the Standards Committee work since January is the revival of aeronautic standardization. Owing to the marked increase in production by aircraft and allied engine, materials and parts companies, and the rapid development of commercial aviation, the interest aroused by the Aeronautic Division has resulted in approval of 13 new aeronautical specifications and the revising of 3 existing specifications. A number of new subjects are also under way, and subdivisions to handle them are being organized.

The formulation and approval of a list of 18 balloon-tire sizes and rims therefore is an equally important accomplishment, made possible by cooperation with the Society by the National Automobile Chamber of Commerce, the Rubber Association of America, the Tire and Rim Association, and the car manufacturers. It is felt that, while much is still to be desired by way of further elimination of sizes, a standard has been agreed upon by all concerned for the first time in many years.

A third important item is the successful promulgation and use of the S.A.E. Viscosity Numbers for crankcase lubricating oils. These numbers have been adopted by more than 40 refiners as a means for designating the viscosity of their products, and are specified in the instruction-books of the majority of the large automobile manufacturers.

Meetings

The following division and subdivision meetings held since the last Annual Meeting have resulted largely in reports to be acted upon by the Standards Committee on June 26:

Aeronautic Division
  Subdivision on Instrument Mountings
Ball and Roller-Bearings Division
Engine Division
  Subdivision on Carbureter Flanges
Iron and Steel Division
Lighting Division
  Subdivision on Bases, Sockets and Connectors
Lubricants Division
Motorcoach Division
Parts and Fittings Division
  Subdivision on Felt
Passenger-Car Division
  Subdivision on Leaf Springs
Production Division
Tire and Rim Division

Nine divisions are submitting 39 reports to the Standards Committee in June, of which 21 are new specifications, 17 are revisions, and 1 is for cancellation. These reports include 2 new production standards which will be published separately to conform to the style of the production standards already issued.

The reports approved at the 1928 Summer Meeting of the Society will be submitted to final letter-ballot of the voting members on adoption and if adopted will be published in pamphlet form, the page size being identical with the present S.A.E. Handbook. This method is followed because the Handbook is now published annually instead of semi-annually. These semi-annual reports will be incorporated in each succeeding issue of the Handbook, bound in complete form. A salient feature of the 1928 edition of the S.A.E. Handbook is the complete thumb-indexing of the various sections, which have been rearranged and regrouped, to facilitate ready reference.

Sectional Committees

The Society has accepted sponsorship for no sectional committees other than those listed in the Annual Report printed on p. 249 of the February, 1928, issue of The Journal. The Sectional Committee on Ball Bearings has made considerable progress toward ball-bearing standards that probably will become world-wide standards. It is possible that a report on such international standards will be completed in time for the Annual Meeting next January. The Sectional Committee on Motor-Vehicle Lighting Specifications, although authorized, has not been and probably will not be organized for some time, as the work involved is still largely in the research stage of development. The Sectional Committee on Numbering of Steels had reported unanimously against establishing a standard general system for numbering steels for all industries and was discharged. The Sectional Committee on Small Tools and Machine-Tool Elements has become very active, having 10 projects under way, for which working technical committees have been or will soon be organized. The other sectional committees for which the Society is a sponsor or on which it is represented have made varying degrees of progress.

American Engineering Standards Committee

This organization of National groups, of which the Society is an active member, has made progress, particularly with regard to its organization and procedure. The revision of the A.E.S.C. Constitution and Rules of Procedure, referred to in the report in the February, 1928, issue of The Journal, is nearing completion, the principal changes contemplated being that the administrative and financial functions will be vested in an Executive Board or Board of Directors composed of ranking industrial executives, while the approval of standards and questions of standardization procedure will be a function of the present Main Committee. It is proposed to change the name of the latter to the Standards Council. The major change in the Rules of Procedure is to provide for the organizing of autonomous sectional committees, for which no sponsors are to be appointed and which will report directly to the proposed Standards Council of the A.E.S.C.

International Standardization

The only present active project that is regarded of international scope is that of standardization of ball-bearings, as reported in the February Journal. Considerable increase in standardizing activities abroad has been noted, and particularly the adoption of current S.A.E. Standards by foreign countries in many cases.

General Interests

The number of committees of other organizations or interests on which the Society is represented remains about as reported last February, considerable progress having been made during the first half of this year by most of them.

H. M. Crane,
Chairman

TREASURER'S REPORT

In the accompanying tables the financial condition of the Society on May 1, 1928, and for the 7 months of the fiscal year from Oct. 1, 1927, to May 1, 1928, is compared with the corresponding period ended April 30, 1927.

TREASURER'S REPORT

	Oct. 1, 1926, to May 1, 1927	Oct. 1, 1927, to May 1,1928
Budget	$220,733.34	$222,250.00
Actual Income	222,900.86	222,859.15
Gross Income over Budget	2,167.52	609.15
Budget Expense	213,441.67	217,175.00
Actual Expense	203,266.20	220,018.37
Unexpended Income	19,634.66	2,840.78
Cash	33,337.60	19,658.32
Accounts Receivable	17,490.18	21,594.00
Accounts Payable	262.50	298.90
Balance of Assets over Liabilities	194,435.81	209,297.30
Securities on Deposit with the Chemical National Bank of New York—Book Value	185,279.82	202,016.38
Market Value	191,564.54[a]	212,749.38[b]

[a] As of April 2, 1927.
[b] As of April 4, 1928.

COMPARATIVE BALANCE SHEET AS OF APRIL 30, 1928, AND APRIL 30, 1927

Assets	1928	1927	Increase	Decrease
Cash	$19,658.32	$33,337.60		$13,679.28
Accounts Receivable	21,594.00	17,490.18	$4,103.82	
Securities	202,016.38	185,279.82	16,736.56	
Accrued Interest on Securities	2,590.84	2,060.71	530.13	
Inventories	1,193.70	1,201.60		7.90
Furniture and Fixtures	2,210.46	2,419.86		209.40
Items Paid in Advance, Charges Deferred	7,199.88	8,139.56		939.68
TOTAL ASSETS	$256,463.58	$249,929.33	$6,534.25	
Liabilities and Reserves				
Accounts Payable	$298.90	$262.50	$36.40	
Dues and Miscellaneous Items Received in Advance	40,195.73	38,664.40	1,531.33	
Reserves Set Aside for Anticipated Expenses	6,671.65	16,566.62		9,894.97
General Reserves	206,456.52	174,801.15	31,655.37	
Net Unexpended Income	2,840.78	19,634.66		16,793.88
TOTAL LIABILITIES AND RESERVES	$256,463.58	$249,929.33	$6,534.25	

INCOME AND EXPENSE COMPARISON—7 MONTHS ENDED APRIL 30

Income	April	1928	1927	Increase	Decrease
Dues and Subscriptions	$7,712.71	$50,802.96	$48,236.66	$2,566.30	
Affiliated Appropriations	625.00	4,375.00	4,375.00		
Interest and Discount	791.53	5,808.99	5,347.87	461.12	
Initiation Fees	2,080.00	11,950.00	11,690.00	260.00	
Advertising Sales—S.A.E. JOURNAL	15,526.00	128,852.00	129.743.00		891.00
Advertising Sales—S.A.E. HANDBOOK	11,000.00	11,000.00	8,850.00	2,150.00	
Miscellaneous Sales	2,837.83	9,256.20	14,658.33		5,402.13
Profit from Sales of Securities		814.00		814.00	
TOTAL INCOME	$40,573.07	$222,859.15	$222,900.86		$41.71
Expenses					
Publications	$10,823.54	$55,754.44	$47,327.09	$8,427.35	
Sections	1,302.59	8,099.57	7,431.20	668.37	
Research	1,544.36	9,647.82	8,343.41	1,304.41	
Employment Service	302.90	1,926.50	2,008.76		82.26
Standards	2,754.43	15,361.35	12,628.14	2,733.21	
Meetings—Net Cost[1]	913.76	20,235.76	16,025.32	4,210.44	
Cost of Membership Increase	890.30	7,838.81	6,638.61	1,200.20	
Cost of Advertising Sales—S.A.E. JOURNAL	4,733.56	37,598.93	37,345.09	253.84	
Cost of Advertising Sales—S.A.E. HANDBOOK	1,998.62	2,100.39	1,428.11	672.28	
Cost of Miscellaneous Sales	868.91	4,291.42	9,095.14		4,803.72
Operation and Maintenance Committee	0.25	166.31	76.50	89.81	
Production Committee	0.07	145.46	72.22	73.24	
Army Ordnance Advisory Committee		30.61		30.61	
General Expense	8,075.29	56,821.00	54,846.61	1,974.39	
TOTAL EXPENSES	$34,208.58	$220,018.37	$203,266.20	$16,752.17	
Net Unexpended Income	$6,364.49	$2,840.78	$19,634.66		$16,793.88

[1] Ticket sales and other receipts deducted.

BUDGET COMPARISON—7 MONTHS ENDED APRIL 30

		7 Months Ended April 30			
Income	Budget 12 Months	Budget	Income and Expense	Over Budget	Under Budget
Dues and Subscriptions	$87,000.00	$50,750.00	$50,802.96	$52.96	
Affiliated Appropriations	7,500.00	4,375.00	4,375.00		
Interest and Discount	10,000.00	5,833.33	5,808.99		$24.34
Initiation Fees	17,500.00	10,208.34	11,950.00	1,741.66	
Advertising Sales—S.A.E. JOURNAL	225,000.00	131,250.00	128,852.00		2,398.00
Advertising Sales—S.A.E. HANDBOOK	18,000.00	10,500.00	11,000.00	500.00	
Miscellaneous Sales	16,000.00	9,333.33	9,256.20		77.13
Profit from Sales of Securities			814.00	814.00	
TOTAL INCOME	$381,000.00	$222,250.00	$222,859.15	$609.15	
Expenses					
Publications	$93,750.00	$54,687.50	$55,754.44	$1,066.94	
Sections	11,200.00	6,533.33	8,099.57	1,566.24	
Research	19,500.00	11,375.00	9,647.82		$1,727.18
Employment Service	4,000.00	2,333.33	1,926.50		406.83
Standards	25,050.00	14,612.50	15,361.35	748.85	
Meetings—Net Cost[2]	24,600.00	14,350.00	20,235.76	5,885,76	
Cost of Membership Increase	13,600.00	7,933.33	7,838.81		94.52
Cost of Advertising Sales—JOURNAL	69,050.00	40,279.17	37,598.93		2,680.24
Cost of Advertising Sales—HANDBOOK	3,500.00	2,041.67	2,100.39	58.72	
Cost of Miscellaneous Sales	10,500.00	6,125.00	4,291.42		1,833.58
S.A.E. Operation and Maintenance Committee	750.00	437.50	166.31		271.19
S.A.E. Production Committee	750.00	437.50	145.46		292.04
Ordnance Advisory Committee			30.61	30.61	
General Expense	96,050.00	56,029.17	56,821.00	791.83	
TOTAL EXPENSES	$372,300.00	$217,175.00	$220,018.37	$2,843.37	
Net Unexpended Income	$8,700.00	$5,075.00	$2,840.78		$2,234.22

	Gross	Cost	Net Income	Relation of Cost to Income Actual, Per Cent	Budget, Per Cent
Initiation Fees	$11,950.00	$7,838.81	$4,111.19	56	78
Advertising Sales—JOURNAL	128,852.00	37,598.93	91,253.07	29	31
Advertising Sales—HANDBOOK	11,000.00	2,100.39	8,899.61	19	19
Miscellaneous Sales	9,256.20	4,291.42	4,964.78	46	66

[2] Ticket sales and other receipts deducted.

The books of accounts were audited as of March 31, 1928, by Haskins & Sells, who report that the accounts were all correct.

C. B. WHITTELSEY,
Treasurer

Why Overproduction in Oil?

THE investment in the petroleum industry is large: $5,000,000,000 is invested in production; $3,000,000,000 in refineries; $1,500,000,000 in marketing; $900,000,000 in pipe lines; $300,000,000 in tank cars and $600,000,000 in steamers—all told, a total investment of $11,300,000,000.

About 1 per cent of our 320,000 producing oil-wells produce 41 per cent of our National crude-oil production; 78 per cent of our wells produce 9 per cent of our oil. One hundred wells in the greater Seminole sector in Oklahoma in 1926 produced an average of 1000 bbl. a day and caused a break in the price of oil that affected 318,000 other oil wells. At the close of 1927, 200 wells at Seminole were producing so much oil that they have taken all of the profit from old producing territories representing an investment of $750,000,000.

I doubt if the steel industry or any other industry could stand up under such a situation; and the petroleum industry represents twice as much invested capital as the steel industry and has been developing at the rate of five times the new capital investment in the steel industry for more than a decade past.

The petroleum industry operates under a condition in which absolute certainty of governing supply is physically impossible. It costs as much to drill a dry hole as it does to drill a gusher!—exactly, an average cost of $18,725. This business of drilling a hole down to a theoretical pool of oil is, at the best, purely speculative. Fully 67 per cent of the wells completed during the last 7 years have been dry holes, gas wells or small producers. A small producer is a well that produces no more than 1 bbl. of oil per day. This means a gross income from such a well of less than $2 a day. We have in the United States fully 250,000 of such small wells. The industry has invested $1,000,000,000 in dry holes since 1909.

The drilling for oil is a hazardous business at the best; during the last 18 years the dry-hole average for all drilling operations east of California has been 22.3 per cent. Each year sees that average steadily but very surely increasing, but this is inevitable as newer fields are more clearly marked out and as the search for newer fields takes the wildcatter further afield. Since 1913 drilling costs have increased 300 per cent and this, naturally, makes wildcatting a more expensive operation.

It is not entirely unlikely that the next decade may bring forth a scientific and accurate method of determining whether a well will be productive before it is drilled; within the next decade it is altogether likely that the normal production curve of an oil well may be materially increased. —Frank B. Fretter, president National Refining Co., in Union Trust Co. organ *Trade Winds*.

Diesel-Engine Manufacture

A RAPIDLY rising trend of sales since 1921 indicates that the Diesel engine in the United States has passed from the experimental to the production stage of manufacture. Prolonged experimentation has overcome many of the obstacles to a broad application for industrial and transportation purposes of the theoretically efficient principles embodied in the heavy-oil engine.

Over 40 companies are more or less actively engaged in the production of Diesel and semi-Diesel engines in this Country. There are on the market today horizontal and vertical two-cycle and four-cycle engines, each of which may be single or double-acting. For certain purposes some of these types are noncompetitive, but in the majority of the cases they are interchangeable. Each again, moreover, may be of the trunk-piston or the crosshead type, and in each case the fuel may be injected by air or mechanical pressure. These general types are, of course, in turn differentiated by a multitude of patented devices for improvements of a minor nature.

Sales have shown a rising tendency in the last 4 or 5 years. Until 1921 the growth of Diesel-engine sales, though steady, was extremely slow. Since then there has come a wider recognition of its economies and the trend of production has risen rapidly. According to the Bureau of the Census, the output of Diesel engines has increased from a total of 330 engines, aggregating 89,039 hp., in 1921, to 4101 engines of 409,390 hp. in 1925. Although later figures are not available, trade compilations indicate that production in the last 2 years has been sustained at the high level of 1925. These figures include a group of heavy-oil engines variously known as "hot-bulb," "hot-plate" or semi-Diesel engines.

Until 1923 the 100-500-hp. class in point of numbers was the most important single group, although closely seconded by the 50-99-hp. class. In 1925, 45 per cent of the heavy-oil-engine output was rated at less than 50 hp. Many of these were semi-Diesels, reflecting the recent concentration of effort in the production of this type in the low-powered engines.

Reduced Production of Steam Engines

Measured by rated horsepower, the output of steam engines dropped over 50 per cent from 1923 to 1925, while oil engines gained 100 per cent. The value of the heavy-oil engines produced in 1925 was one-half greater than the total investment in steam equipment. Despite heavier initial cost, oil engines are effectively competing with steam in all cases where power requirements are moderate.

Of the 4101 engines produced in 1925, 1105, or 27 per cent, were marine engines, and 2996 were stationary engines. From the standpoint of aggregate power the proportions were roughly the same. While considerable attention has been devoted recently to marine engines, production for miscellaneous stationary uses is still of greater importance.

It was early discovered that heavy-oil engines were almost ideally suited to the power requirements of the oil pipe-lines of the West and Southwest. Cheap fuel, direct connection of crankshaft to pump plunger, and the reliability of the heavy, slow-moving Diesel that permitted uninterrupted operation for months at a stretch, amply justified the policy of substituting oil engines for older steam equipment. Today there are nearly 1000 installations totaling 240,000 hp. of Diesel engines in this work. Since 1917 it is reported that practically all new pipe-lines built have been equipped with Diesel engines. In many other instances Diesel and semi-Diesel engines have been used to power water, sewage and irrigation pumps.

Another field that has made good use of the Diesel engine is that of the central power-station. Many of the plants of smaller capacity are municipally owned and in stations of this type the oil engine has fully justified by superior operating economies its considerably higher initial costs. A number of installations have also been made to handle peak loads in larger power-houses. It is estimated that half the central stations in the Country are now equipped with Diesels, although, of course, these engines supply only a small fraction of the total power so generated. Refrigeration plants, mines and quarries, flour mills, textile plants, cotton gins and fertilizer works, among many others, have installed the heavy-oil engine. The competitive position of the Diesel is best in those cases where power requirements are not sufficient to obtain the lowest rate from a central power-house.

Transportation Fields for Oil Engines

Low fuel-costs, a higher economic speed than an equivalent steamship, and markedly increased cargo space have established for the motorship a fine competitive position in ocean transportation. In the world at large there are some 4,000,000 gross tons of motorships afloat, and of the tonnage under construction more than one-half is being equipped with Diesel engines.

There are probably more tugs in operation than any other single type of ship in the world and American harbors in particular are thronged with them. Diesel power is peculiarly well adapted to boats of this class since, by fuel economy and the avoidance of standby losses, fuel bills are cut to one-third those of equivalent steam tugs. Many tugs have been equipped with oil engines for service in harbors, rivers, bays and open sea.

Closely allied is the ferryboat class. With electric drive, the Diesel has come virtually to monopolize new construction in this line. Intercoastal freight and passenger vessels afford good opportunities for capitalizing oil-engine economy, and several Diesel-driven vessels are in this service. The Western rivers, the Great Lakes, the bays and sounds of the Country abound with craft which could profitably utilize the Diesel engine.

As at present developed, there seems to be a useful field for the Diesel locomotive in switching, branch-line work and low-speed heavy-freight hauling. Its flexibility, cleanliness and high tractive force at low speeds recommend it for work of this kind. Rapid expansion, however, is not an immediate prospect. Considerable experimentation remains to be done before the Diesel will be suitable for main-line work, while the possession of extensive coal properties and habits of purchasing will prevent the buying of Diesel engines in large numbers for branch-line operation. Nor does the Diesel compare as favorably with the electric locomotive as it does with steam. The electric locomotive shows only slightly higher fuel-costs, is little more expensive and is considerably lighter.

A number of rail-cars equipped with Diesel engines are being operated successfully in Canada, and there are a few in service abroad. In the United States, although installations of rail-cars have been numerous, these are mostly equipped with gasoline engines.

Census figures show a drop in average value per Diesel-engine horsepower from $93 in 1921 to $68 in 1923 and $54 in 1925. This decline cannot be attributed entirely to lower costs of production; it reflects increasing competition among manufacturers as well and narrowing margins of profit. —*Commerce Monthly.*

Operation and Maintenance

Mechanical Data Sheets

Suggestions To Aid Compilation and Maintenance of Standard System Requested

ONE of the foremost problems discussed by the Operation and Maintenance Committee since its organization is the provision of means for compiling a standard system of mechanical data sheets that will afford the service stations and the motor-vehicle-fleet operators an immediate and reliable check on changes made by the manufacturers of the vehicles they operate, and that can be used also in properly specifying replacement parts. The success of such a system is dependent upon proper initiative on the part of the manufacturers in sending out data regarding changes made, and upon how well the details of its application can be worked out. This work was assigned to J. F. Winchester, a member of the Committee, and he has submitted the following outline of what the Committee has under way, so that all members of the Society may know the plans and aid the work.

Mr. Winchester invites discussion and suggestions for such improvements in the form shown herewith as may be in order. Obviously, a comprehensive report can be prepared only if based on a representative cross-section of the requirements of the fleet-operating members, and the practices of factory engineering-departments and service branches. Such members, including those connected with motor-truck and motorcoach manufacturers who are familiar with this subject, are earnestly requested by the Society to submit to Mr. Winchester, through the Society's Standards Department, constructive criticism of the form here submitted and of the methods suggested for using it. This will aid him in preparing a more definite report to the Committee. The report should be completed sufficiently in advance of the National Transportation Meeting, Oct. 16 to 18, 1928, so that it can be distributed to the members and be considered by the Operation and Maintenance Committee before its presentation. Interested members are therefore urged to send data and suggestions to the Standards Department as soon as possible.

Cooperative Effort Needed

In brief, regarding large or small fleets of motor-vehicles, Mr. Winchester says that the majority of operators consider the number of days in service to be one of the most vital problems of economical operation which, on certain classes of vehicle in competition with established means of transportation, can be brought about only by keeping a vehicle in service over a period of years. This results in the average manufacturer having to build up what he calls supply or service stations, the idea being to maintain constant touch with field conditions and to have on hand a supply of parts that will readily serve for replacement purposes.

As Mr. Winchester has been in close contact with this phase of operation, it appears to him that there remains one link that could connect the factory, its service stations, and the ultimate consumer more closely than is possible under present conditions, having in mind that the ultimate consumer may be the fleet owner or the individual car-operator. Therefore, he proposes to eliminate unnecessary delays of parts replacement and to assure more constant service from the vehicle itself by forming a liaison between the manufacturer, the service stations, and the ultimate consumer.

Suggested Form of Sheet

For this purpose the accompanying form is suggested. It covers the specifications of an individual vehicle. Mr. Winchester believes that such a record, if placed in the hands of the various groups concerned, will be recognized as an indispensable factor in economical operation if one takes into consideration the lack of standardization that exists in the automotive-transportation industry today. It is apparent that, in the majority of instances, the only part which is standardized is the chassis assembly itself. Details of other portions of the vehicle may be changed to care for current improvements or, in many cases, these changes may be based upon detailed specifications received from the fleet operator himself, which it is well to record and place in a convenient form for future reference. He thinks that detailed changes in basic specifications are logical, because various operators have different operations to contend with and engineers have varying viewpoints upon the engineering problems involved.

Recognizing that standardization on any part of equipment as a whole throughout the Country is out of the question, it becomes necessary, says Mr. Winchester, that the three groups involved, namely, the factories, the service organizations and the operators, have placed in their hands duplicate information on each vehicle, which will assist them in solving future problems and in overcoming the difficulties which arise through changes in the personnel of the various organizations. The adoption of such a form would involve practically no expense for any individual. In the case of the manufacturer, if adopted in the proper spirit, it could be used as a final Inspection Sheet and Factory Record. If placed in the hands of the factory service-organizations and the individuals to whom the vehicles have been sold, it would result in both being better able to coordinate their inventories and their requirements of parts and replacements. It would simply be necessary for the service organizations and the owners to keep their files uptodate, having the original information and filing with it such changes as might be made from time to time.

Coordination with Parts Booklets

According to Mr. Winchester, manufacturers are now sending out carefully compiled instruction booklets with each vehicle, and in many cases carefully tabulated parts lists. It would be possible, by using the parts numbers on the Mechanical Data Sheet, to coordinate it with the parts books that are being supplied. This would tend to simplify materially the ordering of parts after the vehicle has become 4 or 5 years old, and would eliminate the now great possibility of ordering parts for given units on incorrect part-numbers, thus making possible the lowering of clerical expense involved in handling this phase of the business, and would be a definite guarantee against possible lost time to the ultimate consumer by eliminating vexatious delays. Many fleet operators have maintained that such records are indispensable where vehicles have run over a long period, and that their use has saved them thousands of dollars annually, particularly in large fleets. One of the main factors that makes possible this saving is the large turn-over that is taking place in the factory's own service organization, which has resulted in succeeding employes not having reliable reference records as a guide in ordering parts for a given model or make of vehicle.

Final Chassis Record

Order No. _____ Wheelbase, In. _____ Length Back of { Cab ___ Ft. ___ In.
Model No. _____ Weight, Lb. _____ { Seat ___ Ft. ___ In.
Chassis No. _____ Capacity, Lb. _____ { Cowl ___ Ft. ___ In.

DESCRIPTION	MAKE / MODEL / TYPE / PART NUMBER / SERIAL NUMBER
ENGINE	
Make	
Model	
Serial No.	
Bore, In.	
Stroke, In.	
N.A.C.C. Horsepower Rating	
Cylinders	
Bearings, Type	
Main	
Connecting-Rod	
Camshaft	
Crankshaft	
Serial No.	
Pistons, Make	
Type	
Part No.	
Piston-Pins	
Connecting-Rods	
Valves, Make	
Inlet	
Exhaust	
Flywheel	
Crankcase	
Oil-Pan	
Water Covers	
Front Cylinder	
Rear Cylinder	
Cylinder-Head	
Cylinder-Head Gasket	
Fan Bracket	
Engine Supports, Type	
Part Numbers	
Choke	
Governor, Make	
Type	
Part No.	
Serial No.	
Set at, M.P.H.	
GASOLINE SYSTEM	
Gasoline Tank	
Capacity, Gal.	
Strainer	
Filler-Cap	
Vacuum Tank, Make	
Model	
Carbureter, Make	
Serial No.	
Part No.	
Model	
Inlet Manifold	
Air-Filter, Make	
Part No.	
Accessories	
EXHAUST SYSTEM	
Muffler	
Muffler Brackets	
Exhaust Pipe	
Exhaust Manifold	
Manifold Gaskets	
COOLING SYSTEM	
Radiator, Make	
Serial No.	
Part No.	
Fan	
Fan Belt, Type	
Water-Pump Assembly	
Radiator Hoses	
Sizes, In.	
Part Nos.	
Radiator Shutters	
OILING SYSTEM	
Gage	
Level Indicator	
Oil-Pump Assembly	
Oil-Filler	
Chassis Lubrication	
Oil-Filter	
ELECTRIC SYSTEM	
Magneto, Make	
Model No.	
Serial No.	
Part No.	
Impulse Starter	
Magneto Coupling	
Generator, Make	
Type	
Serial No.	
Voltage	
Starting-Motor, Make	
Type	
Serial No.	

DESCRIPTION	MAKE / MODEL / TYPE / PART NUMBER / SERIAL NUMBER
Voltage	
Battery, Make	
Type	
Voltage	
Serial No.	
Distributor	
Ignition Wiring	
Spark Coil	
Switch	
Horn Button	
TRANSMISSION	
Clutch, Make	
Type	
Part No.	
Clutch Gear	
Transmission	
Serial No.	
Sliding Gears	
Low Speed	
2nd Speed	
3rd Speed	
4th Speed	
Reverse Idling	
Clutch Shaft	
Countershaft	
Gears	
1st Speed	
2nd Speed	
3rd Speed	
4th Speed	
Countershaft Drive-Gear	
Is Transmission Shaft Fitted for Power Take-Off?	
Bearings	
Gearshift Lever	
DRIVE	
Propeller-Shaft, Front	
Propeller-Shaft, Rear	
Universal-Joints	
Make	
Front Sprocket	
No. of Teeth	
Drive Chains, Type	
Size	
Make	
Part No.	
Jackshaft	
Assembly No.	
Gear Ratio	
Pinion	
Gear	
Serial No.	
CONTROL	
Steering-Gear, Make	
Model	
Serial No.	
Part No.	
Drag-Link	
FRONT AXLE	
Assembly No.	
Serial No.	
Wheels, Make	
Part No.	
Tires, Make	
Size	
Type	
Wheel Bearings, Make	
Inner	
Outer	
Race	
FRAME	
Make	
Serial No.	
Part No.	
REAR AXLE	
Serial No.	
Assembly Part No.	
Radius-Rods	
Wheels, Make	
Type	
Part No.	
Tires, Make	
Size	
Type	
Rear Sprocket	
No. of Teeth	
Differential	
Type	
Bearings, Make	
Bevel-Drive Gear	
Pinion Gear	

DESCRIPTION	MAKE / MODEL / TYPE / PART NUMBER / SERIAL NUMBER
Reduction Gear	
Worm	
Worm Gear	
Housing No.	
Type	
Gear Ratio	
Rear-Wheel Bearings	
Inner	
Outer	
Race	
SPRINGS	
Part No.	
Front	
Rear	
Number of Leaves, Make	
Front	
Rear	
Bushings	
Helper-Springs	
Spring-Clips	
Front	
Rear	
Shackles	
Part No.	
Front	
Rear	
Type	
BRAKES	
Service Brakes	
Make	
Type	
Location	
Drums	
Shoes	
Lining Size	
Hand Brake	
Make	
Type	
Location	
Drums	
Shoes	
Lining Size	
SPEEDOMETER	
Make	
Model	
Head	
Pinion Gear	
Swivel Joint	
Drive Gear	
Shaft	
Elbow	
Adapter	
Driven From	
BODY	
Cab, Make	
Type	
Part No.	
Seat	
Dash	
Body, Make	
Type	
B.P. No.	
Length	
Width	
Height	
Tail Gate	
Fenders	
Paint Description	
Lettering	
EQUIPMENT	
Hoist	
Type	
Serial No.	
Power Take-Off	
Power Take-Off Mountings	
Tire Pump, Make	
Winch	
Serial No.	
Driving-Tower Assembly	
Tower Ratio	
Head-Lamps, Make	
Part No.	
Head-Lamp Bracket	
Lens, Make	
Size	
Side-Lamps	
Tail-Lamp	
Searchlight	
Prestolite	
Tool Box	
Horn	
Bumpers	

(Note below special features not covered in the list)

_____

_____

Factory Delivery Date _____ Freight Car No. _____ Customer _____
Destination _____ Branch Delivery Date _____ Address _____
Inspector _____ Driver _____ _____

Transportation Fundamentals

R. E. Plimpton[1] Emphasizes Necessity for Continuous Intensive Study of the Subject

A PROBLEM so broad and far-reaching that it demands the best attention of all members of the Society is now before its Operation and Maintenance Committee. In its maximum aspect this problem would involve the organization of the varied industries concerned with the application or utilization of motor-vehicles, to establish and codify the important principles of management required for the sound development of this heterogeneous transportation facility.

The minimum aspect of the problem is already being attacked by the members of the Committee, who, as already mentioned in THE JOURNAL, are preparing individual reports on such subjects as handling of drivers and mechanics, standard records for mechanical information, and relation of important accessories to maintenance. This sort of work is about the least the Society can do, if it is to supply any distinctive professional information and inspiration to the large portion of the membership whose life is tied up with the business of motor transportation. But the question comes up more and more persistently: Should the Society be the channel for making a start toward taking up the problem in its maximum aspect, on the upper levels rather than the lowest level possible?

Large-scale motor-transportation installations have grown wild in recent years, the work of the Committee has shown. Many individual examples have been developed along sound lines, and there has been a tendency in the petroleum, department-store and other industries, toward adoption of the practices followed by the most successful members. But there has been no wide effort to compare methods, to subject them to needed criticism, to make known the best and most enduring. To carry out this process of comparison, a high order of scientific thinking is essential and the task certainly is worthy of the Society's best efforts, so far as organization and supervision are concerned.

A preliminary study indicates that some outside and non-partisan research group, such as has been built up at several of the large universities as part of their transportation or business training, might be the best equipped to handle such a project. Certain of these groups have been approached—others may be consulted later—and have signified their interest in taking up the work, provided, of course, that proper financial support is forthcoming. The source of this "support" has also received attention, although any campaign to secure working funds must naturally be deferred until the project has emerged more concretely from its present formative stage.

TWO SCHEMES PROPOSED

Out of many ideas submitted, two schemes have emerged to give the project definite form. Both contemplate a searching study of the larger motor-transport operations, private, contract and common carrier, of both freight and passengers. The size of the installations to be included will have to be determined as part of the study, but in any event the needs of the small operators will receive every consideration.

The first scheme would break the ice by making what, in effect, would be a survey of one year's work of the larger motor-vehicle carriers, collecting information to show the nature of the business organizations, type and amount of service given, nature and location of such facilities as terminals, shops, garages and offices, as well as rolling stock of the automotive type, and the territory covered, with an outline of street and highway conditions. Incidentally, financial data would be collected, but only that of a general nature, such as total operating-expense, to picture the extent of the operations. In fact, all the data mentioned would be intended to bring out common characteristics of all these installations. The information would be valuable, it has been said, in formulating "the economic principles and technical practices necessary for the development of a coordinated and economically sound motor-transport industry."

The second scheme would seek to go to the heart of the situation through a study of operating expenses and net earnings of motor-transportation companies. Detailed income, profit and loss, and balance-sheet statements, would be collected from typical installations, checked, analyzed, and used as a basis of significant facts. This approach—through a financial study—is put forward as the best method of crystallizing the problems of the industry. It is appreciated that no common yardstick is now available for comparing the financial reports of different types of motor-transportation companies. Such a yardstick, call it a classification of accounts, a cost-keeping system or what you will, can best be evolved, it is believed, by the collection and interpretation of actual results.

As intimated before, these two schemes are being studied by our Committee, which is not committed to either one. In the past the Committee work, so far as accounting is concerned, has been conducted on the basis that the first step was to develop a common yardstick. Two or three tentative classifications were worked out by members of the Committee last year, and others are being formulated by this year's members; but no system has been approved by the Committee for submission to the Society. The main reason for this has been the complexity of the whole problem, and the measures on foot, as described here, to secure expert assistance in their solution. However, the Committee realizes the necessity for pressing forward, and it will do everything possible to expedite the work, consistent of course with securing sound and permanent progress. But now is the time for every interested member to come forward with comments on the problem itself, the solutions proposed here, or others that may occur. These comments are heartily invited and should be sent to the office of the Society, marked for the attention of the Committee.

[1]M.S.A.E.—Associate editor, *Bus Transportion*, McGraw-Hill Publishing Co., Inc., Chicago; chairman, Operation and Maintenance Committee of the Society.

Standardization Activities

Transmission Lubricants

Division Recommends Taking Viscosities at 100 Instead of 210 Deg.

AT the June 7 meeting of the Lubricants Division, the proposed elimination of the minimum flash and the maximum pour-test from the present S.A.E. Specifications for Transmission Lubricating Oils, thereby changing the series to a viscosity classification as a recommended practice, was favorably voted on. This places the transmission lubricating oils on the same basis as the crankcase lubricating oils.

After considerable discussion concerning the temperature at which the viscosity ranges should be given, 100 deg. fahr. was agreed upon as the most logical, and tentative values for the ranges were chosen. The reasons for favoring 100 instead of 210 deg. fahr. as the point at which viscosities should be taken are as follows:

(1) Normal operating temperatures of rear-axle or transmission lubricants of passenger-cars are below 210 deg. fahr.

(2) Low-temperature characteristics are of much more importance than high-temperature characteristics in determining the desirable qualities of a transmission and rear-axle lubricant.

(3) Oils from different fields, having the same viscosity at 210 deg. fahr., will show extremely wide variations in viscosity at low temperatures.

(4) Oils from different fields, having the same viscosity at 100 deg. fahr., will not show as wide variations in viscosity at low temperatures. In other words, if the classification is based on viscosities at 100 deg. fahr., oils falling in any one S.A.E. Viscosity Range will be much more nearly alike at operating temperatures for both summer and winter than if viscosities were taken at 210 deg. fahr.

(5) The only objection to the use of the 100-deg. fahr. value is the large viscosity values which are obtained. It was felt that the specifying of the Furol values as well as the Saybolt values will eliminate this objection. While Furol values have not been in general use in the automotive testing laboratories, they are of value for testing heavy lubricants and have been used widely by the refiners.

All present were in agreement that the serial numbers should be 90, 120, 180 and 200, as these numbers are already in commercial use for transmission oils, and do not conflict with the crankcase-oil viscosity numbers.

To illustrate the advantages of the 100-deg. fahr. temperature, an eastern oil having a viscosity of 95 at 210 deg. fahr. will have a viscosity of 1050 at 100 deg. fahr., while a western oil of the same viscosity at 210 deg. fahr. will show a viscosity of 3500 at 100 deg. fahr. The variation at low temperatures would be even greater. These same two oils at 50 deg. fahr. would have viscosities of 8500 for the eastern oil and 100,000 for the western oil. By making the classification at an intermediate temperature, such as 100 deg. fahr., the variation at either extreme temperature is decreased.

If we base our classification on viscosities at two temperatures, we shall be favoring the oil which has the viscosity-temperature slope which has been chosen, putting all other oils under a commercial handicap.

The series first proposed was to show viscosity ranges at 210 deg. fahr. and to include a 200 oil having a viscosity range of 190 to 210. The proposed series of four oils would have had a total viscosity spread of 80 to 210 at 210 deg. fahr. At 100 deg. fahr. the spread for all oils would have been 650 to 30,000. This would have been considering an Eastern oil at the bottom of the range and a Western oil at the top of the range.

The series finally proposed was for viscosity ranges at 100 deg. fahr., the proposed four oils to have a spread of 900 to 9000.

The proposed series of viscosity-numbers and values is as follows:

TRANSMISSION LUBRICATING-OIL VISCOSITY NUMBERS

(*S.A.E. Recommended Practice*)

General.—The numbers cover petroleum oil suitable for the lubrication of transmission and differential gears, worm drives, and roller and ball-bearings used in connection therewith. Compounded lubricating oils containing products other than those derived from petroleum are not dealt with in this list.

Viscosity No.	Viscosity Range at 100 Deg. Fahr.	
	Saybolt Universal	Furol
90	900–1300	90–130
120	1700–2500	170–250
160	3000–4500	300–450
200	5000–9000	500–900

Oils with viscosities falling between the ranges specified shall be classified in the next lower grades.

Reference Temperature

Information on Present Practice in the Industry Desired for Use in Determining a Standard

AT the meetings of the International Committee of Weights and Measures and the General Conference on Weights and Measures, held in Paris in September and October of last year, the matter of international agreement on a standard temperature for the intercomparison of industrial standards of length for precision gage-blocks, graduated scales and lead screws, for example, was referred to a committee of five to report before March 1, 1929.

The Committee is constituted of representatives of the United States Bureau of Standards; the Laboratoire d'Essais du Conservatoire des Arts et Metiers, Paris; the National Physical Laboratory, Teddington, England; and the Physikalisch-Technische Reichsanstalt, Charlottenburg; together with Director Guillaume, of the International Bureau. At the conference in Paris, 68 deg. fahr. (20 deg. cent.) was in general favored by all countries represented except Great Britain, which indicated 62 deg. fahr. (16 2/3 deg. cent.), and France, where both 32 deg. fahr. (0 deg. cent.) and 68 deg. fahr. (20 deg. cent.) are in use.

Inquiry is being made by the Bureau of Standards regarding the attitude in America toward accepting 68 deg. fahr. (20 deg. cent.) as a standard. To assist the Bureau in determining what the practice of the automotive industry is, the Standards Department of the Society urges members, particularly those connected with the larger companies, to send information as to what reference temperature they use, what temperature they feel should be approved and whether they would be willing to change to 68 deg. fahr. if they are not already using that temperature.

Council Meetings in May and at Quebec

A SESSION of the Council was held in Indianapolis on May 29, those attending being President Wall; First Vice-President Strickland; Second Vice-Presidents Dickinson, Woolson and Schuler; Past-President Hunt; and Councilors Sparrow, Whittington, Wooler and Veal.

A financial statement as of April 30, 1928, was submitted. This showed a net balance of assets over liabilities of $208,297.20, this being $13,861.39 more than the corresponding figure on the same day of 1927. The gross income of the Society for the first 7 months of the fiscal year amounted to $222,-859.15, the operating expense being $220,018.37. The income for the month of April was $40,573.07. The operating expense during the month was $34,-208.58.

The election of 86 members, 6 grade transfers, 2 reinstatements, 7 reapprovals and 1 change in record of name on which the Council had acted by mail vote, were confirmed. Seventy-one additional elections to membership were approved, as well as 15 transfers in grade of membership. Six reinstatements to membership were approved, and 3 applications were reapproved.

The following subjects were assigned to Standards Committee Divisions as indicated:

Lighting Division—Fixed-Focus Incandescent Lamps

Production Division — Cylindrical Plug and Thread-Gages, Ring Thread-Gages, and Tool-Holders and Tool-Post Openings

The appointment of Harold G. Smith to the Engine Division was approved.

It was reported that as of May 22, 1928, 5445 members had paid Society dues as compared with 5462 on the same date of last year, and that 3425 members had paid Section dues as compared with 3135 on the same day of last year.

Tore Franzen and D. W. Stewart were named as Society representatives on the American Society of Mechanical Engineers Special Research Committee on Mechanical Springs.

June Council Meetings

Three sessions of the Council were held at Quebec last month during the week of the Summer Meeting, the following being present: President Wall, First Vice-President Strickland, Second Vice-President Dickinson, Past-President Hunt, and Councilors Veal, White, Wooler and Whittington.

The financial statement as of the end of May was considered, this showing a net balance of assets over liabilities of $208,116.40, the amount being $11,735.25 more than the corresponding figure on the same day of 1927. Details of this financial report are given elsewhere in this issue of THE JOURNAL. At present the expenses of the Society for its activities are just about equal to its current income. Current expenses are authorized by the budget for the fiscal year, but at the end of May the income had been $4,000 less than had been contemplated according to the budget. The expenses for the first 8 months of the present fiscal year have been $18,000 more than they were for the corresponding months of the last previous fiscal year; the principal increased expense having been for publications, standards and research, with relatively little increase in general expense.

The election of 56 members, 5 grade transfers, 1 reapproval and 1 reinstatement, on which the Council had acted by mail vote, were confirmed. Thirty additional elections to membership were approved, as well as 8 transfers in grade of membership and 3 applications for reapproval.

Reports were made on plans for meetings to be held during the present administrative year.

C. W. Spicer was named as a representative of the Society on the Sectional Committee on Small Tools and Machine-Tool Elements.

The resolutions passed at the Summer Meeting session of the Sections Committee, referred to elsewhere in this issue of THE JOURNAL, were presented in person by Chairman Apple, of the Sections Committee, and discussed at length; with no definite action taken, however, owing to the complexity of matters involved and the fact that inasmuch as one of the resolutions would involve Constitutional amendment to put it into effect, no time would have been saved by submission of a Constitutional amendment proposal at the Summer Meeting last month. One of the resolutions related to the status of Sections entertainment expense so far as Council approval is concerned. This resolution will be considered by the Finance Committee in its study on the budget for the coming fiscal year.

The other resolution covered the recommendation of the Sections Committee that the necessary steps be taken to make the Sections and the National dues, for members residing in this Country, one charge of $20. Raising the amount of specified compulsory dues, of course, involves amendment of the Constitution of the Society. In view of the fact that the provisions as to such amendment require opportunity for discussion at two meetings of the Society, the change contemplated by the Sections Committee could not have been reduced to practice by the time of the beginning of the next fiscal year, Oct. 1; the next Annual Meeting of the Society being scheduled to be held in January of next year. With regard to Junior members, whose annual dues now are $10, there was no detail discussion as to how they would be affected by the "one charge," if the generally contemplated change were made.

Reports as to financial budgets for the coming fiscal year were submitted by several of the Sections, and discussed. Similar reports from other Sections are being awaited, and upon receipt of them the whole matter will be analyzed and studied by the Finance Committee. The Council indicated that in general it favors making more money available than heretofore for defrayal of Sections activities as a whole.

In connection with publications, the report set forth in this issue of THE JOURNAL on the result of a meeting held at Quebec last month by members of the Publication Committee, in conference with other interested Society members, was received. This report covered the publishing of the TRANSACTIONS in a new form, with the same type-page as that of THE JOURNAL, but lesser over-all page-size to meet library-cabinet conditions. At a previous meeting the Council had expressed general approval of this idea. The report related also to the preparing of a cumulative index of the publications of the Society from the time of their inception—a subject of more or less long standing; and also to points regarding the amount and nature of papers to be printed in THE JOURNAL and the TRANSACTIONS. These matters will be studied further by the Publication Committee, there having been no quorum of the Committee in attendance at the Summer Meeting; and also by the Finance Committee. The report submitted to the Council at Quebec was, however, accepted so far as it covers the ramifications involved.

Regarding the TRANSACTIONS and the manner of distributing Parts of them to the members as issued, the Council favors returning to the practice of several years ago, if this shall be warranted by the financial condition of the Society; that is, TRANSACTIONS covering the periods for which members have paid dues would be available to members wishing copies of them without payment of charge in addition to the dues.

The report of the Standards Committee, as formulated at its session held on June 26, was approved for submission at the Business Session of the Semi-Annual Meeting of the Society held last month.

Personal Notes of the Members

The A B C of Flight

Members of the Society will note with interest the publication of a book entitled, The A B C of Flight, by W. Laurence LePage, with a foreword by the **Hon. Edward P. Warner.** Both men, prominent in aviation circles, are members of the Society and are well-known to many of their fellow - members through their active participation in Society and Section affairs.

Dealing with the fundamental principles of flight and their application, the book is of decided interest to a variety of readers. One reviewer, in the *New York Times* Book Review, May 27, 1928, characterizing the work as "not only informed and accurate but also simple and practical," said in part that, if the book should be widely read, it ought to exert a very considerable influence on the general attitude toward aviation, and therefore upon its commercial development during the next few years. For the author is so calm and sure in his exposition of the reliability of the air as a medium and of the airplane as a means of travel that he can hardly fail to inoculate the reader with his own confidence.

Mr. LePage has been engaged in aeronautical pursuits since 1920, when he joined the scientific research staff of the aerodynamic department of the National Physical Laboratory in England. Three years later he came to this Country and became research associate in the department of aeronautics at the Massachusetts Institute of Technology. He was editor of *Aviation* from 1925 to the early part of last year, when he resigned to accept the position of assistant to the vice-president of Pitcairn Aviation, Inc.

Mr. LePage became a Junior Member in 1924. Mr. Warner was elected Member in 1917. A brief biographical sketch of the latter was printed in these columns last month. Mr. LePage has been a member of the New England Section and of the Metropolitan Section and now is active in the Pennsylvania Section. In 1925 he was secretary of the New England Section. At the 1925 Aeronautic Meeting he delivered a paper, The Light Airplane and Low-Powered Flying, which was printed in THE JOURNAL in November of that year.

Preston Accepts New Position

In accepting the position of vice-president and chief engineer of the Victor Body Corporation, Lansing, Mich., Victor Preston brings to an end an affiliation of five and a half years with the Hayes Hunt Corporation, Elizabeth, N. J., but continues his 17 years of association with **H. Jay Hayes,** president of the new company.

His early engineering experience, gained while serving his apprenticeship with Stareys, Ltd., of Nottingham, England, his native country, awakened his interest in coach and automobile body-building, an interest which was to predominate in his future activities. In 1910 he came to America to accept a position as draftsman with the Kelsey Herbert Co., of Detroit. One year later he entered upon his long association with the Hayes Ionia Co., Grand Rapids, Mich, as body engineer and general superintendent. He was subsequently appointed chief body engineer and eventually transferred in this capacity when the Hayes Hunt Corporation of Elizabeth, N. J., was incorporated.

Mr. Preston became a Member of the Society in 1921, and of the Metropolitan Section in 1924. The same year that he joined the Society he was elected to serve on the Passenger-Car Body Division of the Standards Committee.

Elmer A. Sperry Honored

Elmer A. Sperry, famed for the success of his practical applications of the gyroscope, was the recipient of a signal honor at a recent meeting of the American Society of Mechanical Engineers in Pittsburgh. He was awarded the Holley medal in recognition of a "great and unique act of genius of an engineering nature that has accomplished a great and timely public benefit," namely, the invention of the gyroscopic compass. The presentation was made by George I. Rockwood, the donor of the medal. At the same meeting Mr. Sperry was nominated as president of the A.S.M.E. for the year beginning next December.

In the course of his distinguished career as an engineer, Mr. Sperry has been conducting research on internal-combustion engines since 1892. An early builder of automobiles, he constructed one electric vehicle in 1895 and 80 electrics in the succeeding three years. He is now chairman of the board of the Sperry Gyroscope Co., Brooklyn, N. Y.

Mr. Sperry joined the Society in 1916 and the Metropolitan Section in 1925. During his membership he has taken a keen interest in the direction of Society affairs. In 1917 he was a Finance Committee member; in 1919 he was elected Second Vice-President representing aviation engineering, and in 1923 served on the House Committee. A valuable contribution to the Society BULLETIN was made by Mr. Sperry in December, 1916, in the form of an interesting article entitled Aerial Navigation over Water. This article was later published in Part I of the 1917 TRANSACTIONS.

New Aeronautic Consulting Firm

Archibald Black, a prominent figure in aviation circles, has announced the formation in New York City of a new company, Black & Bigelow, of which Mr. Black will be president and general manager. The company has been established for the purpose of rendering engineering and business services to aircraft operators.

Mr. Black was born in Scotland and was originally engaged in electric powerplant design and construction, having been connected with several firms there and in the United States. He has been a resident of this Country since 1906 and became identified with aeronautic engineering in 1910. Since about 1915 he has devoted himself exclusively to this field and has been associated in various responsible capacities with several well-known firms. In 1919 Mr. Black gave up his position as chief engineer of the L W F Engineering Co., College Point, N. Y., to lend his services to the Navy Department in the City of Washington, where he became identified with the Bureau of Construction and Repair, in charge of aeronautic specifications. At the close of the war, he opened engineering offices, in partnership with D. R. Black, in the City of Washington. In 1921 he served as consulting engineer to the Air Mail Service. Some time later he entered the engineering field independently, establishing himself as a consultant in air-transport engineering in Garden City, N. Y. He continued in this sphere until the recent formation of Black & Bigelow, Inc.

Mr. Black is the author of Transport and Aviation and of many interesting articles on various phases of aeronautic engineering, which have appeared from time to time in a very extensive list of technical publications, including *American Machinist, Aviation, Aero Digest, Mechanical Engineering,* and *Automotive Industries.* Among those published in THE JOURNAL, as well as in the corresponding TRANSACTIONS of the Society, are Aircraft Radiators, June, 1919; Exhaust Headers and Mufflers for Airplane Engines, August, 1918; and Heat-Treating of Brazed Fittings for Aircraft, March, 1920.

Mr. Black has been an active participant in Society activities since his election to membership in 1917. He joined the Metropolitan Section in 1927. His interest has largely centered in the Standards Committee work, and he has

(*Continued on p.* 34)

Applicants for Membership

The applications for membership received between May 15 and June 15, 1928, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ACKLIN, WILLIAM C., secretary and treasurer, Acklin Stamping Co., *Toledo, Ohio.*

AIERS, ARTHUR JOSEPH, production manager, Riley (Coventry) Ltd., *Coventry, Warwicks, England.*

BAEKELAND, GEORGE, director, assistant to president, Bakelite Corporation, *New York City.*

BAKER, ROYAL J., chemist, Wadhams Oil Co., *Milwaukee.*

BARTLETT, K. J. G., foreign representative, Bristol Aeroplane Corporation, Ltd., *Bristol, England.*

BECKER, ARMAN E., in charge of lubrication research laboratories, Standard Oil Development Co., *Elizabeth, N. J.*

BERRY, HERBERT F., garage foreman, California Petroleum Corporation, *Los Angeles.*

BIGELOW, RAYMOND DEMAR, salesman, Watson-Ledet Motors, Inc., *Vicksburg Miss.*

BROWN, JAMES WESLEY, district manager for northern California, Moreland Motor Truck Co., *San Francisco.*

CANNING, WILLIAM SHIELDS, engineering director, Keystone Automobile Club, *Philadelphia.*

CAMPBELL, GEORGE W., proprietor, Pacific Radiator & Fender Works, *Oakland, Cal.*

CASLER, R. H., representative, Westinghouse Air Brake Co., *Boston.*

CLARE, WILLIAM A. vice-president, Houde Engineering Corporation, *Buffalo.*

CLARK, SHELDON A., staff engineer, Sinclair Refining Co., *New York City.*

COLE, ROY E., assistant chief engineer, Dodge Brothers, Inc., *Detroit.*

COLEMAN, THOMAS E., superintendent, Six Wheel Co., *Philadelphia.*

DAGENAIS, J. EDWARD, active service representative and chief inspector, General Motors Export Co., *Montevideo, Uruguay, South America.*

DEMAREST, CORBIN Z., 616 Decatur St., *Brooklyn, N. Y.*

DIBELKA, HENRY G., engineer, Kingsley-Miller Co., *Chicago.*

DYKE, HERBERT H., member of firm, Dyke, Holden & Schaines, *New York City.*

EAST, JOHN RALPH, mechanical engineer, Holliday Head Light Co., *Jackson, Miss.*

FAWCETT, EARL WHITE, manager, Independent Lubricating Co., Inc., *Topeka, Kansas.*

FERRIS, HAROLD WELDON, service manager, Maine Road Equipment Co., *Portland, Maine.*

FITZPATRICK, A. W., service manager, Hart Parr Co., *Charles City, Iowa.*

FULTZ, PARK C., reclamation supervisor, Chrysler Corporation, Highland Park Plant, *Highland Park, Mich.*

GIBSON, HARRY LAURENCE, technical advisor, Scenic Line Airways, *Salt Lake City, Utah.*

HAWN, GEORGE L., SR., general sales engineer, The Piston Ring Co., *Muskegon, Mich.*

HAZARD, JAMES HOWARD, student, Central High School, City of Washington.

HEDLEY, THOMAS ARTHUR, head instructor of gas engine, tractor and machine-shop departments, Provincial Institute of Technology and Art, *Cayuga, Ont., Canada.*

HEIMAN, JOHN M., garage foreman, Cudahy Packing Co., *Los Angeles.*

HILTON, J. H., superintendent of machinery, Carolina Coach Co., *Raleigh, N. C.*

HOLADAY, WILLIAM M., research engineer, Standard Oil Co. of Indiana, *Whiting, Ind.*

HUMBLE OIL & REFINING CO., *Houston, Texas.*

INGOLD, GUSTAVE, service manager, eastern territory, Auburn Automobile Co., *New York City.*

JONES, MAJOR RALPH ERNEST, U. S. A. instructor, Tank School, *Fort Leonard Wood, Md.*

JONES, REGINALD FAIRCHILD, assembly superintendent, Melbourne Motor Body & Assembling Co., Proprietary, Ltd., *Victoria, Australia.*

JOHNSTON, WILLIAM J., vice-president, Wisconsin Motor Co., *Milwaukee.*

KNAPP, THOMAS L., salesman, industrial department, Pennzoil Co., *Los Angeles.*

KNIGHT, JAMES ALFRED, garage manager, Broadmoor Hotel Co., and superintendent, Pikes Peak Auto Highway Co., *Colorado Springs, Colo.*

LESTER, EDWARD, shop superintendent, Shell Co. of California, *Seattle.*

LEVON, WALTER P., body layout draftsman, Dodge Brothers, Inc., *Detroit.*

LUND, PHILO W., district representative, Hutto Engineering Co., Inc., *Detroit.*

MAISTRE, MAURICE, engineer in testing laboratory, International Motor Co., *New York City.*

MAZARELL, RICHARD L., draftsman, American Telephone & Telegraph Co., *New York City.*

MCCASLIN, HENRY C., resident engineer, Durant Motors of Canada, Ltd., *Toronto, Canada.*

MCINTYRE, GORDON, chief chemist, Imperial Oil Refineries, Ltd., *Sarnia, Ont., Canada.*

MERRITT, CHARLES H., 3RD, engineer in standards department, The Autocar Co., *Ardmore, Pa.*

MEYER, AMOS F., draftsman, Climax Engineering Co., *Clinton, Iowa.*

MOTT, E. PARKER, engine designer, International Motor Co., *Long Island City, N. Y.*

MURRAY, ROY J., garage owner, operator, mechanic, Funk & Murray, *Lacrescent, Minn.*

NEAL, J. P., equipment engineer, Texas State Highway Department, *Austin, Tex.*

OVERBEKE, JOHN WILLIAM, aeronautical draftsman and designer, Glenn L. Martin Co., *Cleveland.*

PENKOFF, GEORGE, salesman, International Harvester Co., *San Francisco.*

PLACE, ALFRED W., vice-president, supervisor of sales and engineering, Universal Machine Co., *Bowling Green, Ohio.*

PRANCE, ALVIN W., trim engineer, Ford Motor Co., *Dearborn, Mich.*

RATCLIFFE, JOHN GORDON, service superintendent, A. D. Gorrie & Co., Ltd., *Toronto, Canada.*

RICHTER, OTTO, JR., electric engineering apprentice, The Buda Co., *Harvey, Ill.*

ROBE, WALTEN BURDETT, vice-president, Egal Metal Products Co., *Baltimore, Ohio.*

RODE, FRED J., factory manager and chief engineer, Marquette Tool & Mfg. Co., *Chicago.*

RUDOLPH, ANTHONY C., sales, The Bassick Co., *Bridgeport, Conn.*

SMITH, VICTOR C., superintendent of repair shop, Standard Oil Co. of New York, *New York City.*

SPRING, CARL WILLIAM, sales engineer, lubricating oil department, Shell Co. of California, *San Francisco.*

STIRK, JOHN HARDACRE, traffic manager, Birmingham Cooperative Society, *Birmingham, England.*

TAYLOR, HAROLD M., district manager, Firestone Tire & Rubber Co., *Detroit.*

THURNER, R. J., president and general manager, Thurner Heat Treating Co., *Milwaukee.*

TOLEIK, JOHN A., sales manager, Subox, Inc., *New York City.*

USHER, LAURENCE STANLEY, manager, Kermath Mfg. Co. of Canada, Ltd., *Toronto, Ont., Canada.*

VICK, PRESLEY G., instructor in charge, automobile mechanics department, Trade School, Hampton Normal and Agricultural Institute, *Hampton, Va.*

WATERHOUSE, WILLIAM ERNEST, purchase engineer, European region, General Motors Export Co. of New York, *New York City.*

YORK, RAYMOND THOMAS, school instructor, Chevrolet Motor Co., *Baltimore.*

Applicants Qualified

The following applicants have qualified for admission to the Society between May 10 and June 9, 1928. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

BARNER, JAMES D. (S M) engineer officer, United States Navy, VF Squadron 5-B, Fleet Air Base, *San Diego, Cal.*

BAUER, CHARLES A. (J) chief development engineer, Indian Motocycle Co., *Springfield, Mass.*

BECKWITH, DOUGLASS W. (A) secretary and general manager, Positive Lock Washer Co. of America, Ave. A and Miller Street, *Newark, N. J.*

BEHLEN, ALBERT (A) tool and plant engineer, Copeland Products, Inc., *Detroit;* (mail) 639 Harmon Avenue.

BENNETT, JAMES C. (M) manager, automotive department, Associated Oil Co., 79 New Montgomery Street, San Francisco; (mail) 1360 59th Street, *Emeryville, Cal.*

BERRY, CHARLES H. (A) storekeeper (automotive), equipment department, Division of Highways, State of California Department of Public Works, Vineland and Cumpston Streets, *North Hollywood, Cal.;* (mail) 5140 Cahuenga Boulevard.

BION, JOHN W. (A) assistant purchasing agent, New York Edison Co., 130 East 15th Street, New York City; (mail) 104-59 108th Street, *Richmond Hill, Long Island, N. Y.*

BIXLER, MARSHALL HAYNES (M) general manager, Fremont Metal Body Co., Lime Street, *Fremont, Ohio.*

BOEHME, CHARLES F. (J) shop foreman, Ked-Law Motor Co., 2518 South Michigan Avenue, *Chicago;* (mail) 5317 South Artesian Avenue.

BOOM, CLIFFORD ARCHIE (M) general superintendent, Howard Automobile Co. of Los Angeles, 1367 South Figueroa Street, *Los Angeles.*

BROOKS, NEIL E. (J) draftsman, Continental Motors Corporation, *Detroit;* (mail) 1405 Lenox Avenue, Apartment 304.

BROZYNA, KARL (F M) chief engineer, research, inspection, Austin Motor Co., Ltd., Birmingham, England; (mail) Wingrove and Norman Road, Northfield, *Birmingham, England.*

CARNEY, T. (M) assistant motor engineer, Willys Overland Co., *Toledo.*

CARSON, A. E. (J) service engineer, Delco-Remy Corporation, Anderson, Ind.; (mail) 576 Drayton Avenue, West, *Ferndale, Mich.*

CRAIG, CHESTER A. (M) director, salesman, Ryan Sales Engineering Co., 82 Lothrop Avenue, *Detroit.*

CURTS, ROBERT M. (J) engineer, New Jersey Zinc Co., Palmerton, Pa.; (mail) 370 12th Avenue, *Paterson, N. J.*

DALEY, THOMAS J. (A) secretary, sales representative, Multibestos Co., Walpole, Mass.; (mail) 930 Taylor Avenue, *Detroit.*

DINSMORE, CLARENCE B. (A) practical development engineer, A. C. Spark Plug Co., *Flint, Mich.;* (mail) 718 Myrtle Street.

DREW, HAROLD (F M) motor designer, Vauxhall Motors, Ltd., Luton, *Bedfordshire, England.*

DYE, KENNETH R. (J) assistant engineer, bus division, Murray Corporation of America, 1424 Aberle Street, *Detroit;* (mail) 14765 Dexter Boulevard.

FORWARD, DR. CHAUNCEY B. (A) president, Oil Refining & Development Co., *Urbana, Ohio.*

FREERS, SIDNEY L. (J) layout draftsman, motor division, Willys Overland Co., *Toledo;* (mail) Room 311, Y. M. C. A.

FREUD, ARTHUR (A) sales representative, Matthews Mfg. Co., 104 Gold Street, Worcester, Mass.; (mail) 507 Fifth Avenue, Room 703, *New York City.*

GIVEN, GUY C. (M) research chemical engineer, E. I. duPont deNemours & Co., Parlin, N. J.; (mail) *Parlin, N. J.*

GRAHAM, ELMER J. (A) superintendent of transportation, Public Service Co. of Colorado, 900 15th Street, *Denver;* (mail) 2249 South Cherokee Street.

GRISELL, L. HOBART (M) chief engineer, Gar Wood, Inc., 415 Connecticut Avenue, *Detroit;* (mail) 230 Massachusetts Avenue.

HALPINE, CHARLES GRAHAM (S M) lieutenant commander, United States Navy, Bureau of Navigation, Navy Department, City of Washington; (mail) U.S.S. Wright, care Postmaster *New York City.*

HARRIS, THERON D. (M) manager, motor-transportation department, Marland Companies, *Ponca City, Okla.*

HEALD, BENJAMIN F. (A) mechanical draftsman, Research Department, Chilton Class Journal Co., 56th and Chestnut Streets, Philadelphia; (mail) 7022 Aberdeen Road, *Upper Darby, Pa.*

HOPWOOD, CHARLES E. (J) draftsman, Consolidated Gas, Electric Light & Power Co., *Baltimore;* (mail) 1216 North Luzerne Avenue.

HOWARD, ROY (A) president, Roy Howard, Ltd., 821 Hornby Street, *Vancouver, B. C., Canada.*

IMLACH, JOHN STEVENSON (A) owner, 324 Catherine Street, *Ottawa, Ontario, Canada;* (mail) 55 Wilton Crescent.

INGHAM, EDWARD S. (A) manager, retail sales and service, Budd Wheel Co., E. G. Budd Mfg. Co., 12141 East Charlevoix Avenue, *Detroit.*

JUPP, W. B. (M) chief engineer, rail-car, International Motor Co., Anable Avenue and 34th Street, Long Island City, N. Y.; (mail) International Motor Co., 25 Broadway, *New York City.*

KERBY, FLOYD GEORGE (J) body engineering representative, contacting with production and vendors, Studebaker Corporation of America, Brush and Piquette Streets, *Detroit.*

KOLLINEK, THEODOR (F M) chief constructor, Knorr-Bremse Automobil Gesselschaft, Berlin-Lichtenberg, NeueBahnhofstr 9-17, Germany; (mail) Motzstrasse, 19, *Berlin W., Germany.*

KYSER, HOWARD N. (J) junior laboratory engineer, Studebaker Corporation of America, *South Bend, Ind.;* (mail) 1217 Miami Street.

LAUER, RODNEY E. (M) chief draftsman, LeBaron-Detroit Co., 1551 Harper Ave., *Detroit;* (mail) 2269 Garland Avenue.

LAWSON, IVER NORMAN, JR. (A) treasurer, chief engineer, Ryan Aeronautical Corporation, 411 Union Building, *San Diego, Cal.*

LINDGREN, IVAR C. (A) service manager, Roller Motor Co., 219 West Sixth Street, *St. Paul, Minn.;* (mail) 1121 St. Clair Street.

LUTZ, FRED. F. (A) superintendent of buildings and supplies, Bell Telephone Co. of Pennsylvania, 210 Pine Street, *Harrisburg, Pa.*

MASON, HAROLD R. (A) assistant to experimental engineer, Detroit Lubricator Co., 5842 Trumbull Avenue, *Detroit.*

MATHAUER, EDMUND GEORGE (J) designer, American Car & Foundry Motors Co., Detroit; (mail) 1119 Forestdale Road, *Royal Oak, Mich.*

MCCOY, WILLIAM HOWARD (M) experimental production manager, General Motors Corporation, Research Laboratories, General Motors Bldg., *Detroit;* (mail) 2911 West Grand Boulevard.

MILLER, PEARLE NELSON (M) assistant body engineer, Edward G. Budd Mfg. Co., Charlevoix Street, *Detroit;* (mail) 3653 Devonshire Road.

MORSE, HERBERT G. (M) electrical engineer, General Electric Co., 1 River Road, *Schenectady, N. Y.*

MULLER, JACK (J) testing engineer, American Machine & Foundry Co., Second Avenue, *Brooklyn, N. Y.;* (mail) Y. M. C. A., 1841 84th Street.

NACKER, O. M. (M) motor development engineer, Cadillac Motor Car Co., Detroit; (mail) 28 Elm Park Avenue, *Pleasant Ridge, Mich.*

NICHOLSON, GRIFFITH C. (A) vice president, engineer, Hydro-Check Corporation, *Monroe, Mich.*

NIEMAN, HENRY W. (M) experimental engineer, Bethlehem Steel Co., *Bethlehem, Pa.*

PANKRATZ, A. C. (A) president, general manager, Quality Aluminum Casting Co., Lincoln Avenue, *Waukesha, Wis.;* (mail) Lincoln Avenue, Box 178.

PENNSYLVANIA PETROLEUM CO., INC. (Aff.) 15th and Charlotte Streets, *North Kansas City, Mo.,* Representative: Kelley R. Johnston, vice-president.

POLLAK, JOSEPH (A) president, manager, Joseph Pollak Tool & Stamping Co., 81 Freeport Street, *Dorchester, Mass.*

ROBERTS, EARL HERBERT (A) in charge of testing and experimental work, Kermath Mfg. Co., 5890 Commonwealth Avenue, *Detroit;* (mail) 707 Pallister Avenue.

ROSAN, JOSE (J) engine designer, Johnson Motor Products Co., 518 West 57th Street, New York City; (mail) 2752 89th Street, *Jackson Heights, Long Island, N. Y.*

ROYSTON, JOSEPH R. (A) secretary, treasurer, works manager, American Nut & Bolt Fastener Co., 2029 Doerr Street, *Pittsburgh.*

SCHAUB, WILLIAM FULTON (J) manager, New London Coach Co., *New London, Conn.;* (mail) 52 Water Street.

SCHLIEDER, V. W. (A) secretary, Diamond Motor Parts Co., *St. Cloud, Minn.*

SENKOWSKI, ALEXANDER (F M) assistant technical manager, Polish Skoda Works, P. O. Box 418, *Warsaw, Poland.*

SMITH, PAUL A. (M) mechanical engineer, Barber-Greene Co., *Aurora, Ill.*

STANLEY, FRANK J. (A) general manager, Michigan Steel Casting Co., Atwater and St. Aubin Streets, *Detroit.*

STEPHENSON, THOMAS W. (J) automobile body draftsman, detailer, Ford Motor Co., Dearborn, Mich.; (mail) 408 Adeline Avenue, *Detroit.*

SUTTON, JAMES A. (J) chassis layout and design, American Car & Foundry Motors Co., 5718 Russell Street, *Detroit.*

TRBOJEVICH, NIKOLA (M) research engineer, Timken-Detroit Axle Co., 100-400 Clark Avenue, *Detroit.*

VEENENBOS, ANDRIES L. (M) tool designer, Chevrolet Gear & Axle, 1480 Holbrook Avenue, *Detroit;* (mail) 496 Ashland Avenue.

VOILES, OSCAR MONROE (M) 453 Manotee Avenue, *Hazel Park Station, Mich.*

WALTON, HERBERT R. (A) vice-president, Hassler-Detroit Co., 2-219 General Motors Building, *Detroit.*

WEDEKIND, JOSEPH CHARLES (J) mechanical draftsman, Studebaker Corporation of America, *Detroit;* (mail) 151 Seward Avenue.

WESSELHOFF, CLARENCE E. (M) chief draftsman, Ford Motor Co., *Dearborn, Mich.;* (mail) 3247 Clairmount Avenue.

WHATMOUGH, WILFRED AMBROSE (F M) managing director, Autostat, Ltd., *London E. C. 1, England;* (mail) 22 Ely Place.

WRIGHT, LEWIS A. (M) assistant patent counsel, Packard Motor Car Co., *Detroit.*

ZAND, STEPHEN J. (M) aeronautical engineer, Ford Motor Co., Dearborn, Mich.; (mail) 5653 Horger Avenue, *Fordson, Mich.*

ZUCK, HARRY E. (J) automotive laboratories, College of Engineering, University of Michigan, *Ann Arbor, Mich.;* (mail) 1436 East Park Place.

Notes and Reviews

AIRCRAFT

Fog. By F. Entwistle. Published in *The Journal of the Royal Aeronautical Society*, May, 1928, p. 342. [A-1]

To penetrate the mystery of that meteorological phenomenon so dangerous to both sea and air craft is the object of this article. The author makes his presentation against a background of 15 years' experience, as he has studied the weather in relation to aviation since the beginning of the World War.

Tracing fog to its source, he assigns two conditions as necessary for its formation: (*a*) a cold surface giving rise to a stratification of the lower atmospheric layers and (*b*) a light wind. His analysis distinguishes seven types of fog: radiation, warm front, sea, land, mixing, high, and smoke fogs. Light is thrown on the probable occurrence of this weather condition by a discussion of the effect of topography, the diurnal and seasonal variation of fog, and its geographical distribution.

A description is given of an instrument for determining the height of fog, and methods are outlined for forecasting fog. The three ways of fog dispersion so far considered, thermal, mechanical and electrical, are, in the opinion of the author, capable of clearing only a small volume of air. That infra-red light has possibilities for successfully penetrating smoke fog is indicated.

A Preliminary Investigation of Supercharging an Air-Cooled Engine in Flight. By Marsden Ware and Oscar W. Schey. National Advisory Committee for Aeronautics Report No. 283. Published by National Advisory Committee for Aeronautics, City of Washington. 11 pp.; 6 illustrations. [A-1]

This investigation is the first of its kind that has been conducted and for which results have been published. Service - training airplanes equipped with production types of Wright-J engines were used, and a National Advisory Committee for Aeronautics Roots-type supercharger was driven from the rear of the engine.

Those quantities that would enable determination of the climb performance to be made were measured, as well as cylinder-head and carbureter temperatures and carbureter pressures.

With the supercharger so geared that ground-level pressure could be maintained to 18,500 ft., the absolute ceiling was increased from 19,400 to 32,600 ft., and the time to climb to 16,000 ft. was decreased from 32 to 16 min. This amount of supercharging did not seem to injure the engine.

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

The Comparative Performance of Roots Type Aircraft Engine Superchargers as Affected by Change in Impeller Speed and Displacement. By Marsden Ware and Ernest E. Wilson. National Advisory Committee for Aeronautics Report No. 284. Published by National Advisory Committee for Aeronautics, City of Washington. 14 pp.; 9 illustrations. [A-1]

Three sizes of Roots-type aircraft-engine superchargers were tested in this investigation. The impeller contours and diameters of these machines were the same, but the lengths were 11, 8¼ and 4 in., giving displacements of 0.509, 0.382 and 0.185 cu. ft. per impeller revolution. The information obtained serves as a basis for examination of the individual effects of impeller speed and displacement on performance and of the comparative performance when speed and displacement are altered simultaneously to meet definite service requirements.

With different sizes of supercharger whose impeller speeds are so related that the same service requirements are met, the individual effects of speed and displacement are cancelled to a large extent and the only considerable difference is the decrease in the power losses with increase in the displacement and the accompanying decrease in speed. This difference is small in relation to the net power of the engine-supercharger unit.

Preliminary Investigation on Boundary Layer Control by Means of Suction and Pressure with the U. S. A.-27 Airfoil. By E. G. Reid and M. J. Bamber. National Advisory Committee for Aeronautics Technical Note No. 286. Published by National Advisory Committee for Aeronautics, City of Washington. 18 pp.; 31 illustrations. [A-1]

Performance characteristics of airplanes would be improved considerably if the departure of the air-flow from the upper surface of airfoils could be made as small at large angles of attack as it is at small angles.

The tests covered in this report constitute a preliminary investigation of airfoil boundary-layer control. Tests were made on a U. S. A.-27 airfoil section with various slot shapes and combinations, and at various amounts of pressure or suction on the slots.

Results obtained indicate that the lift of airfoils can be increased by removing or by accelerating the boundary layer; that removing the boundary layer by suction is more economical than to accelerate it by jet action; that, when not in operation, the suction slots tested had a detrimental effect upon the aerodynamic characteristics of the airfoil, which was not apparent with the backward-opening pressure slots; and that thick, blunt-nose airfoils seem to give best results with boundary-layer control.

La Standardisation des Traitements Thermiques des Aciers de l'Aéronautique. By L. Gazzaniga. *La Technique Moderne*, March 1, 1928, p. 191. [A-5]

Standardization of heat-treatments of steels has been confined, in France, to a few manufacturers of steels and of automobiles. To secure for the aircraft industry the benefits that such standardization will bring, the author has made a carefully planned study, the results of which are presented in this article. All types of steel are included, except those which serve as the raw material only in the manufacture of airplane accessories.

The information developed is incorporated in a table giving a series of heat-treatments, the types of steel appropriate for a given treatment, the mechanical characteristics of such metals, and the uses for which they are suited.

CHASSIS PARTS

Some Notes on Crankshafts. By F. Strickland. Published in *The Automobile Engineer*, May, 1928, p. 182. [C-1]

From his many years of general engineering and automobile experience

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